South Carolina

Centers of Economic Excellence (CoEE)

Comprehensive Program Evaluation 2003-2008

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Executive Summary

In the summer of 2008, the South Carolina Commission on Higher Education (CHE), on behalf of the CoEE Review Board, engaged the Washington Advisory Group (WAG) to prepare a review of the Centers of Economic Excellence (CoEE) Program for the period 2003-2008 with respect to enabling legislation originally passed in 2002 and amended by the South Carolina General Assembly in 2008. The objective was to assess the effectiveness of the program in meeting its statutory goals, not to evaluate the work carried out within the Centers. As part of this process, WAG consultants interviewed over 150 CoEE participants and stakeholders at universities and in the public and private sectors during August through October 2008. This report provides the results of the evaluation.

The evaluation team has found that the CoEE program has had a profound and positive impact on the prospects for economic growth and diversification in the State of South Carolina. It has raised the quality and relevancy of university research, improved the stature of the research universities, and increased collaboration among the universities and between the universities and the private sector. Economic impacts in terms of increased external funding, new job creation, and business location decisions have been significant and can be expected to grow as the program continues and matures.

The key findings regarding the program are:

1. The CoEE Program has brought cutting-edge research programs and equipment, matching funds and competitive research awards, and Knowledge Economy jobs to the state.
2. The CoEEs and Endowed Chairs are of high quality in terms of scholarship, research and economic impact.
3. The CoEE program has transformed the culture of South Carolina's research universities. Collaboration and entrepreneurship are now the norms.
4. The CoEE program has raised the national and international reputations of the universities and made South Carolina more competitive in the global economy.
5. The CoEE program benefits from strong business support, and the industry partners are pleased with the outcomes to date.
6. The CoEE program has solidified relationships among the universities, hospitals, national laboratories, and industry, and has created a statewide network for innovation.
7. A single, integrated statewide economic development plan does not yet exist in South Carolina, but the CoEE program has coalesced around clusters that could be components of such a plan.
8. Graduate education is an industry attractor and a workforce and economic benefit of the CoEEs.
9. The universities have made significant investments in the CoEEs, but they may not be able to continue investing at the same rate in the future.

10. In certain instances, the universities lack the institutional capacity to adequately manage functions and infrastructure associated with the CoEE program.

11. Public awareness of the program is limited and its image and audiences are not yet well-defined.

12. The CoEE Review Board has performed effective oversight with support from the Commission on Higher Education**.**

The evaluation team determined that over 2,000 new jobs have been created or attracted to South Carolina by the CoEE program; that the state's investment has been leveraged more than 3-1 by non-state matching funds and competitive research awards won; and that the program's most significant economic contributions are focused in three industrial sectors: Advanced Manufacturing, Energy and Environment, and Health.

In the course of performing our evaluation, the WAG consultants identified a number of actions that could improve the program's effectiveness and economic impact. We propose 10 high-level recommendations for further assessment and possible implementation:

1. The CoEE program is fulfilling the goals for which it was created, and funding for the program should be continued as a high priority for South Carolina.

2. The program could be more effective if a portfolio approach to CoEE investment were adopted in coordination with other state programs and incentives.

3. Front-loaded funding would accelerate new Center startups and the state's return-on-investment. The General Assembly and the CoEE Review Board should adopt policies to facilitate expedited outcomes.

4. The universities should identify potential funding match partners before a CoEE award is made.

5. The universities could develop creative approaches to fundraising that also enhance program outreach and visibility.

6. The program should increase the focus and emphasis on graduate education as a stimulus for creating a high-tech workforce in South Carolina.

7. A new statewide approach to technology transfer could help the CoEEs commercialize their research results.

8. Regulatory relief is needed to address issues of university services and infrastructure.

9. The program should establish a Council of Chairs and an annual CoEE conference.

10. The program should establish future performance metrics and streamline reporting.

The report also makes recommendations regarding CoEE panel reviews, recruitment of new Chairs, and policies for modifying and for sunsetting Centers, and contains a description of relevant state programs in Kentucky, Georgia, and North Carolina. Implementation of the recommendations should be done in combination with an analysis of all associated impacts and costs.

Our conclusion is that the CoEE program is an extraordinary effort by the state of South Carolina to invest in its Knowledge Economy and is a best-in-kind program that is, or should be, the envy of other states. The state and its senior research universities are to be applauded for nurturing the CoEE program and for deploying it as a powerful tool for the creation of high-wage jobs and improvement in the quality of life of South Carolina's citizens.

Introduction

Scope of the Evaluation

In the summer of 2008, the South Carolina Commission on Higher Education (CHE), on behalf of the CoEE Review Board, engaged the Washington Advisory Group (WAG) to prepare a review of the Centers for Economic Excellence (CoEE) Program for the period 2003-2008

As described in the Evaluation Prospectus, the purpose of this review is "to determine the effectiveness of the program in meeting its statutory goals and objectives" in a "comprehensive report" involving three phases:

> "The first part will be an analysis of program data and materials… The second part will be anecdotal analysis based on interviews with program stakeholders, CHE staff, and campus visits… The third part will be a detailed critique of the CoEE program with general findings, citation of program strengths, and suggestions for program improvements."[1]

Documents Reviewed

The kick-off meeting of CoEE staff and the WAG project team was held in Washington, D.C. on July 14, 2008. The consultants received a large packet of program data and materials prior to this meeting, and reviewed additional material during the course of the evaluation.

The program data and materials analyzed during Phase I of the project included:

- CoEE Enabling Legislation
- CoEE Review Board Guidelines
- CoEE Proposal Process
- CoEE Review Panel Reports
- CoEE Program Operating Budgets and Financial Data
- CoEE Review Board Meeting Minutes
- 2004-2008 Annual Reports
- CoEE Program Auditing Materials
- CoEE Endowed Chairholder Offer Letters
- CoEE Program Marketing Materials
- CoEE Program Media and Press Reports

These documents gave an overview of the research areas and activities, prepared the consultants for the on-site visits and interviews, and provided important background information on program goals,

[1] *South Carolina Centers of Economic Excellence, 2003-2007 Five-Year Program Evaluation Prospectus,* October 2007, p. 4.

accomplishments, and challenges. The consultants would not have received an overall accurate picture of the program, however, without the face-to-face interviews and site visits that ensued.

Interviews and Site Visits

In Phase II the project team made site visits to Columbia, Charleston, Clemson, and Greenville, and interviewed program stakeholders and CHE staff. An alphabetized list of persons interviewed, with titles, is contained in Appendix A. The key categories include:

- University Leaders
- CoEE Review Board Members (past and current)
- General Assembly and State Political Leaders
- CoEE Chairs, Principal Investigators, and Faculty
- University Administrators and Staff
- Private-Sector and Matching Fund Partners
- Review Panel Members
- CHE/CoEE Staff

The project team visited the following CoEE laboratories and facilities:

- Innovista (USC)
- Hollings Cancer Center (MUSC)
- Clinical Simulation Lab (MUSC)
- Hollings Marine Lab at the Fort Johnson campus (NOAA, NIST, S.C. Department of Natural Resources, College of Charleston, MUSC)
- Advanced Materials Center (Clemson)
- International Center for Automotive Research (Clemson)
- Patewood Facility for Regenerative Medicine (Clemson)

Background

The following Comprehensive Program Evaluation 2003-2008 is Phase III of the project and contains a detailed CoEE overview, the evaluation team's findings, and recommendations for program improvements. Appendix B also contains an analysis of other state programs in Georgia, Kentucky, and North Carolina.

Economic Development in South Carolina

South Carolina's economy has historically relied on agriculture, tourism, textiles, and manufacturing. The CoEE program is the state's first and most significant investment in university-based economic development.[2]

In the state's economy and education, South Carolina has:

- A billion-dollar agriculture and food industry but is home to only one Fortune 500 company.
- The lowest high school graduation rate in the country and ranks 45th out of 50 states in percent of the population who are college graduates.
- One of the highest unemployment rates in the nation and ranks 43rd in average annual wage.
- Per capita income that is 82% of the national average, compared to near 100% in the neighboring states of Georgia and North Carolina.

In the health of its citizens:

- South Carolina has the nation's highest rate of sickle cell anemia (two times the national average)
- The state's population is relatively old (more than half of South Carolina citizens are older than 56) and prone to neurodegenerative diseases.
- South Carolina has the second highest mortality rate from stroke, and the fourth highest mortality rate from Alzheimer's disease.[3]
- Cardiovascular disease is the leading cause of death in the state, and kills citizens twice as often as cancer.

South Carolina welcomes newcomers and new businesses, but the state's R&D generation and workforce have generally been inadequate to attract major companies or support new companies that develop in the state.

The long-term economic impact of these trends is shown in the per capita income in a comparison of Columbia SC, Austin TX and Raleigh NC. All three cities are Southern state capitals with large public research universities. In 1970 Columbia had the highest per capita income. In 2000 it had the lowest.

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[2] The CoEE legislation identifies Clemson University, the Medical University of South Carolina, and the University of South Carolina as "senior research universities" eligible for funding. Proposals can be submitted by the universities individually, in collaboration with one another, or in collaboration with other universities in the state.

[3] Centers for Disease Control. Except where noted, the statistical facts and figures in this report come from interviews conducted during the site visits.

The per capita income had risen approximately 53% in Raleigh and 41% in Austin, but only 3.3% in Columbia.[4] What was the difference? Unlike the Research Triangle in North Carolina and the University of Texas in Austin, the universities in South Carolina were not supported or challenged to become major research players. Between 1970 and 2000, Clemson University, the Medical University of South Carolina, and the University of South Carolina were institutions without a robust research enterprise to underpin the state's economic development.

The CoEE program is the first step in a comprehensive Knowledge Economy strategy to address this problem. As Bill Gates, the founder and CEO of Microsoft, has said: "There is an almost perfect correlation between the number of good jobs in a region and the strength of the universities."[5] The aim of the CoEE program is to strengthen the research universities in South Carolina in order to build a foundation for the economic health and well-being of its citizens.

Enabling Legislation

The South Carolina General Assembly created the CoEE program in 2002 as a bold action to stimulate research and development and high-wage job creation.

Table 1 shows the five major pieces of legislation, representing approximately $500 million in total state investment, that the General Assembly has passed to bring talent to the state and establish a network for discovery and innovation[6]. This $500 million investment represents approximately $110 per South Carolina citizen, or $18 per citizen per year over a six-year period. Funding for the CoEE program comes from the South Carolina Education Lottery. Two higher education programs, the Life Scholarship program (for undergraduates) and the CoEE program (for research) have received $532 million and $180 million, respectively, in Lottery funding since 2003.

The backdrop for this infusion of funding has been a significant drop-off in general state funding of higher education. As one interviewee remarked, the state share of research university budgets has fallen from 45% to 21% over the last 12 years. The higher education funding policy of South Carolina appears to be to: a) cut the base level of state support as a percentage of total university budgets; b) fund families through Life Scholarships and other scholarship programs to choose the university qualified students can attend; and c) create incentives through the CoEE program for the universities to raise non-state matching funds for research.

[4] U.S. Census Bureau data.

[5] Quoted in *Clemson World- Online*, Winter 2006, Vol. 59, No. 1 at http://www.clemson.edu/clemsonworld /archive/2006/winter06/feature5.htm.

[6] The data in Table 1 comes primarily from an August 21, 2008 memorandum prepared by Craig H. Parks, Senior Research Analyst, S.C. Senate Finance Committee.

Table 1. Knowledge Economy Legislation

CoEE/Endowed Chairs	
When	2002
Purpose	Provide incentives to the senior research universities to raise capital from non-state sources to invest in endowed professorships to build a knowledge-based economy
Who	Clemson, University of South Carolina, Medical University of South Carolina
How much:	$200 million cap in original legislation; $180 million appropriated to date; revised legislation provides for $30 million per year as long as funding formula is maintained
Research University Infrastructure Bond Act	
When	2004
Purpose	Provide research infrastructure and facility improvements to attract technology-based business and promote economic development projects in cooperation with the universities
Who	Clemson, University of South Carolina, Medical University of South Carolina
How much:	Up to $220 million total; $195.8 million certified for award to date
Venture Capital Investment Act	
When	2004
Purpose	Attract venture capitalists to South Carolina to strengthen the economic base by providing equity, near equity and seed capital through tax credits
Who	Venture capitalists; Venture Capital Authority managed by Department of Commerce
How much:	$50 million in tax credits
Innovation Centers Act	
When	2005
Purpose	Create three university research centers in targeted areas for statewide economic development
Who	South Carolina Research Authority and S.C. research universities
How much:	$12 million
Industry Partners Act	
When	2006
Purpose	Create SCLaunch to help entrepreneurs take ideas to market with seed funding. Businesses and individuals receive state income tax credits for 100% of the donated amount to the Industry Partners Fund.
Who	South Carolina Research Authority
How much:	$6 million over 3 years; $6 million per year thereafter in tax credits
Other	
The Legislature has also made Knowledge Economy investments of $1 million to USC for hydrogen research; $500,000 to Clemson for photonics research; $1 million to USC for nanotechnology; $1.5 million to Clemson for automotive research; $7 million in the 2006 budget for alternative fuels initiatives; $2 million in 2006 for tax credits to buy hydrogen-fueled cars; and $6.6 million for S.C. LightRail.	
ESTIMATED TOTAL COMMITTED BY STATE:	**$500 million**
Per Capita Investment:	**$110 ($18 per citizen per year over 6 years)**

Program Overview

The CoEE program provides funding for the universities to recruit top scientists and engineers to conduct research that will help create well-paying jobs and enhance economic opportunity in South Carolina.

A CoEE typically includes one or more world-class faculty members leading a team of faculty and graduate students. A CoEE has to have appropriate infrastructure, technical staff and sustainable funding resources, and is expected to have a positive impact on other research programs and to support the research objectives of the home institution. The research team helps stabilize the Center and mitigates against "flight" of key investigators. In terms of economic development, the Centers are expected to create and help commercialize technology, attract or create new companies and jobs, and increase the state's per capita income.

The Endowed Chairs are the world-class scientists and engineers who lead the Centers. As the CoEE Program Guidelines state, "The professor must in most cases be a new hire to the institution and emerge as a candidate through a national search." In fact, all of the Endowed Chairs recruited to date have been new hires from outside the state, not current faculty promoted from within. The goal is to raise the national and international profile of South Carolina and to set new standards of excellence at the universities.

The CoEE Matching Endowment is funded by the state and managed by the CoEE Review Board, and the program makes available between $2 million and $5 million for each Center and Endowed Chair. The state funds can be drawn down by the senior research institutions on a dollar-for-dollar basis once non-state matching funds are raised and in hand at the institutions.

The first step in developing a CoEE is the submission of a proposal by a Principal Investigator and colleagues at one of the eligible senior research universities. At this stage, many of the proposed Centers do not have a non-state match commitment, and the Endowed Chair or Chairs have not been identified. The program relies initially on the commitment and vision of the proposal team. The Principal Investigator acts as a proxy for the Endowed Chair and as the administrative lead for the proposal.

All submitted proposals are rated and ranked by outside experts in a two-step process and are then reviewed by the CoEE Review Board. Once the Review Board approves a proposal, the state funding for a new Center is designated.

The CoEE award is a challenge grant for the universities. Once the state money has been placed in the CoEE Matching Endowment and an award has been made, the universities have 18 months in which to secure the non-state pledges, and can be granted up to two six-month extensions. All non-state matching funds must be in hand within 78 months of the state award. In the event the full non-state match is not pledged or realized, the award is terminated and the state money stays in the CoEE Matching Endowment.

The pace of Center development and timing of Endowed Chair recruitment varies considerably from institution to institution and from Center to Center. In some cases the Endowed Chair is recruited early in the process and brings with him/her the faculty, equipment, and technical staff needed to establish the Center. In other cases, the home institution builds the CoEE infrastructure first and hires the Endowed Chair as the last step in the process.

CoEE funding involves a third contributing party – the universities themselves. In addition to the state award and the non-state matching funds, developing a new Center requires a significant investment by the university. To help offset this cost, the CoEE legislation was amended in 2008 to give the CoEE Review Board discretion to allow a portion of the matching funds (currently 60%) to be spent on the direct costs of Center infrastructure, lab outfitting, and salary supplements, etc. This change reflects the two-pronged nature of the program, which supports both Endowed Chairs *and* Centers.

The first investment in a new Center (not including investments by the university) is made when the cash from the non-state match arrives and the draw-down of state funds begins. This can introduce a significant time lag in the development of new Centers (see Figure 7 later in this report). Once the state money is transferred to the university, it must accrue interest for at least one year in the university endowment before it can be used to support a new Chair. Clemson's endowment policy is the most conservative and requires a three-year hold before any proceeds can be used.

The recruiting of Endowed Chairs is done in parallel with the steps described above. Academic recruiting is a courtship process, and it can take as long as two years to convince a world-class scientist or engineer to leave his or her current institution and move to a new university.

For all of these reasons, the time period between the designation of the CoEE award and the job creation payoff is quite long. Commercialization of university research is typically measured in decades, not months or years. South Carolina has been building a foundation for the Knowledge Economy during the first six years of the program, not yet reaping the full rewards. Nonetheless, the CoEE program has been a remarkable success, and the positive impact can be measured even today.

Organizational Roles

The roles and responsibilities for the CoEE Review Board, the Commission on Higher Education, the Technical and On-Site Review Panels, the eligible research universities, and the non-state funding match partners include:

- *CoEE Review Board* - The Review Board has statutory oversight responsibility, manages the process and procedures of the program, and represents the interests of South Carolina to accelerate job creation and enhance economic opportunity in the state. The members are unpaid volunteer appointees of the political leaders of the state.
- *Commission on Higher Education (CHE)* - CHE staffs the CoEE Review Board and supports the oversight and program reporting functions. The CHE also manages the proposal review process and coordinates with the universities in the areas of finance, government relations, and communications.
- *Technical and On-Site Review Panels* – The Technical and On-Site Review Panels provide objective input to the Review Board. The first panel evaluates the scientific and technical merit of the written proposals. The On-Site Review Panel conducts an in-depth review for quality and evaluates the proposals' economic development potential.

- *Eligible Research Universities* – Clemson University, the Medical University of South Carolina, and the University of South Carolina are responsible for preparing quality proposals and raising matching funds. The Centers and Endowed Chairs also work with industry to commercialize CoEE results. The other universities in South Carolina are not eligible to submit proposals directly but may be partners in CoEE proposals.

- *Non-State Funding Match Partners* – The non-state funding match partners have no formal responsibility, but participation by them is critical to the program's success. In addition to contributing money, they may maintain close ties with the Centers, put their names on the Endowed Chairs, and serve as advisors to the research programs and to students. As such, they are important contributors to economic development and job creation.

The South Carolina Research Authority (SCRA) and Department of Commerce share responsibility with the CoEE program for economic development in South Carolina and could play significant roles in support of the CoEE mission. The Department of Commerce can help identify private-sector funding match prospects that would benefit from partnering with the CoEE program as they expand or relocate their business operations in the state. SCRA can be the downstream partner for the CoEE program in the areas of technology transfer, venture investment and commercialization.

Findings

Finding #1 -The CoEE Program has brought cutting-edge research programs and equipment, matching funds and competitive research awards, and Knowledge Economy jobs to the State.

Innovative research is the foundation of the CoEE program, and, since the program began in 2003, South Carolina has successfully built Centers of Economic Excellence in cutting-edge fields that diversify the state's economy and position it competitively in the national and global economy. The full list of the research fields in which CoEE Centers and Endowed Chairs have been awarded is shown in Appendix C. Examples of research focus areas and one-of-a-kind Centers that provide a unique competitive advantage to South Carolina include:

- Clean and alternative energy research involves five CoEEs at USC to support the University's goal of supporting future energy in the state and the nation. The program is a component of a university-wide Future Fuels™ initiative that includes work on nuclear, clean coal, biomass, and environmental sustainability. The CoEEs are focused on hydrogen and fuel cells, solid oxide fuel cells, and environmental approaches to electricity production from coal and nuclear energy. The goal is to establish South Carolina as a research leader in these fields.

- Clemson University International Center for Automotive Research (CU-ICAR) is an advanced technology campus that generates knowledge for the state's automotive and motor sports industry. Four CoEEs in Automotive Manufacturing, Automotive Systems Integration, Automotive Design and Development, and Vehicular Electronic Systems

Integration are involved in R&D and graduate education. Clemson offers the nation's only Automotive Engineering Ph.D. – a one-of-a kind activity that brings distinction to the state.

- The Clinical Effectiveness and Patient Safety CoEE has been established as a statewide network of simulation centers called Healthcare Simulation South Carolina. This unique network allows students and professionals to test their clinical skills and interact with other healthcare professionals in a safe, risk-free environment using models that represent physiologic and pathologic situations of patients of all ages and conditions.

Table 2, "SC CoEE Economic Impact," summarizes the funding leverage, competitive research awards, and job creation impacts of the program to date. During the first six years of the program, the Review Board has designated $175.6 million in CoEE awards, the universities have secured $124 million in non-state matching pledges, and the non-state partners have paid $82.8 million in matching funds.

By successfully leveraging the state and non-state matching funds, the CoEEs have generated more than $122 million in new research funding from competitively-awarded research grants. A portion of this total represents research grants that the Endowed Chairs have brought with them from their previous institutions, and a portion represents new grants that have been won by the Centers directly. Major pieces of research equipment have also been brought to South Carolina by the Endowed Chairs or purchased by the Centers thanks to this research funding.

The $124 million in non-state matching funds and pledges, $122 million in research funding awards, and new, world-class research programs and equipment would not have come to South Carolina without the CoEE program.

The impact of the CoEEs in terms of the more than 2,000 new jobs created has been outstanding. BMW uses a 3.9:1 ratio to calculate the number of new jobs that are created in the local economy in South Carolina with each new BMW job.[7] R&D spending at universities has a similar job creation multiplier effect. According to the Bureau of Economic Analysis of the U.S. Department of Commerce, 36 new jobs are created for each $1 million in new research spending.[8] When the $122 million in new research spending that is directly attributable to the CoEE program is pro-rated over the four-year average life of a research grant, the current annual spending level is approximately $30.5 million**.** Using the U.S. Department of Commerce formula, it is possible to calculate that nearly 1,100 new jobs have been created in South Carolina since 2003 thanks to the CoEE program.[9] Some of the new jobs were created through increased employment at the universities, and others through the Centers' impact on the local economy.

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[7] Trevor Anderson, "BMW Expansion Should Boost S.C. Economy," *Spartanburg Herald-Journal*, March 11, 2008.

[8] As cited in Daniel Hurley, *Tapping State College Research and Development Capacity in Support of State Economic Development, A Higher Education Policy Brief* (American Association of State Colleges and Universities, October 2008), p. 1.

[9] This estimate includes only the job impact of new competitively-awarded research grants attributable to the CoEE program, not the impact of endowment spending from the state and non-state matching funds.

The jobs that have been created through CoEE research funding are a potent near-term economic stimulus for the state. If the level of research funding remains constant or grows, they will also become a permanent part of South Carolina's economy. We project that the amount of new research funding and number of associated new jobs is likely to grow at least twofold as the Centers that have been approved but not yet fully funded come online.

In addition to the new jobs created by university research, the program has helped South Carolina attract 895 new jobs at companies associated with the Centers. Most of these jobs are located in the CU-ICAR campus in Greenville, where Clemson has partnered with BMW, Michelin and Timken, and BMW and Timken have expanded and located new R&D operations in the state. In November 2008, American Titanium Works announced that it plans to build a new $420 million plant with 320 employees in Laurens and to locate 30 more high-wage R&D employees on the CU-ICAR campus.

As shown in Appendix D, the CoEE program has also resulted in the creation of 11 spin-off companies with 40 new employees**.** Appendix D also lists other university spin-offs and shows that the CoEEs are part of a developing innovation ecosystem in South Carolina. The job creation at the spin-off companies has been relatively limited to date, which is characteristic of spin-off companies that are still in an early stage of development.

Table 2. SC CoEE Economic Impact*

COEE Funding	
State:	$175.6 million total designated for award; $66 million drawn down
Non-state match:	$124 million total pledged; $82.8 million received
University contributions:	$89 million
Competitive Research Awards Won	
Total awards won or brought by new Centers:	$122.2 million
Award amount directly attributable to Endowed Chairs:	$69 million
Job Creation	
Jobs created by new research spending:	1,100
Jobs created by company attraction:	895
Jobs created by CoEE spin-off companies:	40
2,035 total new jobs created or attracted by CoEE program	
Summary	
3:1 leveraging of state funds to date: $205 million ($82.8 non-state match + $122.2 competitive research awards won) to $66 million state funds drawn down to date	
* Data reflects totals as of end-FY 2008	

CU-ICAR CASE STUDY

Clemson University's International Center for Automotive Research (CU-ICAR) is regarded as "the quintessential example of what the CoEE program was designed to do," in the words of a former Review Board chair. CU-ICAR has a brand-new research campus along Interstate 85 in Greenville, world-class corporate partners, and a one-of-kind graduate education program for a high-tech workforce in automotive engineering.

How was CU-ICAR created and what lessons does it offer?

In 2002, BMW was already established in South Carolina and wanted to expand. One in six BMW cars sold worldwide was manufactured in the state. Clemson was looking to establish a university presence in Greenville, and 250 acres of land, suitable for a number of purposes, was available along I-85. The combination of circumstances was ideal.

Clemson initially proposed to build a full-scale wind tunnel on the site for research and development by NASCAR race teams. Vice President Przirembel of Clemson pitched the idea to BMW's senior management. The response from BMW was, in effect, "We already have a wind tunnel in Germany and don't need one in the United States. What we are interested in is education, trained U.S. automotive engineers, and an environment in South Carolina that our German engineers will be attracted to."

BMW invested $400 million in its manufacturing plant and received an incentive package worth $80 million from the S.C. Department of Commerce. The incentive package included $15 million for a new BMW Information Technology Research Center that brought several hundreds of new high-paying R&D jobs to South Carolina. The IT Research Center was the first BMW research facility to be located outside Germany.

BMW gave $10 million, matched by $10 million in CoEE funds, for two Endowed Chairs in the new graduate program in automotive engineering. At the request of BMW, the South Carolina Department of Commerce gave Clemson $25 million of construction funds for the new Campbell Graduate Engineering Center next to the BMW IT Research Center on the I-85 site. Clemson subsequently added two more CoEE Endowed Chairs at CU-ICAR with support from Michelin and Timken.

The total CoEE investment in CU-ICAR to date has been $36 million – $18 million in state funding and $18 million in corporate matching funds. Timken subsequently built a second R&D facility on the campus, bringing several hundred additional R&D jobs to the state. By 2008, the four Endowed Chair positions were filled, six junior faculty were hired, and Clemson's new graduate program in automotive engineering opened its doors to the first class of 55 Masters and doctoral degree candidates. The graduate program will grow over time to 100 students and offers the only U.S. doctoral degree in automotive engineering.

Key lessons:

- New graduate education programs tied to the emerging needs of industry are critical to business location decisions and CoEE program success.
- CoEE funding alone did not create CU-ICAR. The CoEE investments were only one part of a larger state incentive package and corporate investment by BMW.
- To replicate the CU-ICAR success, South Carolina should leverage CoEE strengths and assets in coordination with other state incentives. The CoEE program has created significant assets in the industrial sectors of Health, Energy and the Environment, and Advanced Manufacturing that could be part of a business attraction package.

Finding #2 - CoEEs and Endowed Chairs are of high quality in terms of scholarship, research and economic impact.

The premise of the CoEE program is that a small cadre of academic superstars can have a positive impact on economic development. The program places a premium on a scarce and highly valuable resource: talented people. Rich Karlgaard, the publisher of Forbes Magazine, describes the CoEE strategy this way: "Best place to make a future Forbes 400 fortune? Start with this proposition: The most valuable natural resource in the 21st century is brains. Smart people tend to be mobile. Watch where they go! Because where they go robust economic activity will follow."[10]

The CoEE program is still in what one university president calls a "gestational period", with 43 awarded Centers and 21 of 75 approved Endowed Chairs so far recruited. But the economic impact of the Chairs who have been hired has been outstanding. The 21 recruited Chairs are personally responsible for $69 million in new research grants, more than half of the $122 million total new CoEE grants. This level of grant funding is remarkable given that many of the Chairs have been in the state for less than 18 months.

The qualities of the Endowed Chairs recruited thus far include:

- Member (or potential member) of the National Academy of Sciences, National Academy of Engineering, Institute of Medicine, or other prestigious honorific organization
- Funded investigators, often with significant federal awards
- Entrepreneurial temperament; demonstrated connections to industry
- Desire to work with students
- Enthusiasm for the opportunity to create something new and relevant to society

The Endowed Chairs come from top ranked universities (e.g., MIT, RPI, Johns Hopkins, Penn State, Penn, Duke, Emory, UNC Chapel Hill), hospitals (M.D. Anderson; Veterans Affairs), research institutes (Fox Chase Cancer Center), industry (Celanese Research Co., Ethicon, Inc., IBM), national laboratories (Los Alamos, Argonne) and government agencies (DoE, NIH, DoD, NASA, NIST, NOAA). They hold leadership positions in professional societies and organizations, hold patents, and have started companies; for example, in the areas of renewable fuels (Palmetto Fuel Cell Analysis and Design), brain imaging (Cephos), drug discovery and therapeutics (SemiAlloGen, Inc.), regenerative medicine (FirstString), and photonic materials (Tetramer; Advanced Photonic Crystals).

The Endowed Chairs and their CoEE faculty colleagues have also brought or been awarded major equipment (e.g., confocal microscope, femtosecond pulsed laser system, glass fabrication system for optical fibers), prestigious awards (e.g., MERIT Awards from the NIH; NIH Career Investigator Awards), and major grants to South Carolina (e.g., $25 million for a clinical trial related to stroke; a National

[10] Rich Karlgaard, "Where to Get Rich," October 6, 2003 at www.forbes.com/forbes/2003/1006/039.html.

Science Foundation Partnership for Innovation award). They are also prolific authors of scientific papers (e.g., 71 new publications in the Cancer Drug Discovery CoEE alone).[11]

If the newly-hired Endowed Chairs attract external research funding at the same rate as the Chairs that are already in place, the total amount of CoEE research funding is likely to double in the next few years. The South Carolina universities are currently in the running for several multi-million dollar grants, including:

- National Cancer Institute designation (Hollings Cancer Center, MUSC)
- Clinical and Translational Science Award (CTSA)(MUSC and USC)
- National Imaging Data Center for Traumatic Brain Imaging - DoD (Brain Imaging, USC/MUSC)
- DOE Energy Frontiers Research Program (Reifsnider- Solid Oxide Fuel Cells, USC)
- NIH COBRE (Centers of Biomedical Research Excellence, MUSC)

These awards are of a similar scale and prestige to the two National Science Foundation Industry/University Cooperative Research Centers that are already in place in South Carolina, the Center in Engineering Logistics and Distribution, in which Clemson participates, and the Center in Fuel Cells at USC. South Carolina would not be in a position to compete for these pending major grants without the resources provided by the CoEE program.

Finding #3 - The CoEE program has transformed the culture of South Carolina's research universities. Collaboration and entrepreneurship are now the norms.

The collaboration model that has developed through the program is, in the words of one university president, "a non-governance model of coordination." Each university retains its own institutional identity and autonomy, and the three universities bring their collective strengths to the task of building statewide CoEEs.

The inception of the CoEE has heralded an impressive increase in the R&D expenditures at the three research universities, as shown in Figure 1. Since 2002, growth in research activity at both Clemson University and USC has significantly exceeded the growth rate in total US R&D expenditures, while MUSC closely matches the overall US growth rate. While not directly attributable to the CoEEs, this performance is indicative of the change in culture at the institutions, and the increase in competitiveness and success in obtaining research funding.

[11] The start-up companies, research equipment, scientific papers, etc. listed here reflect the accomplishments of CoEE faculty as well as Endowed Chairs.

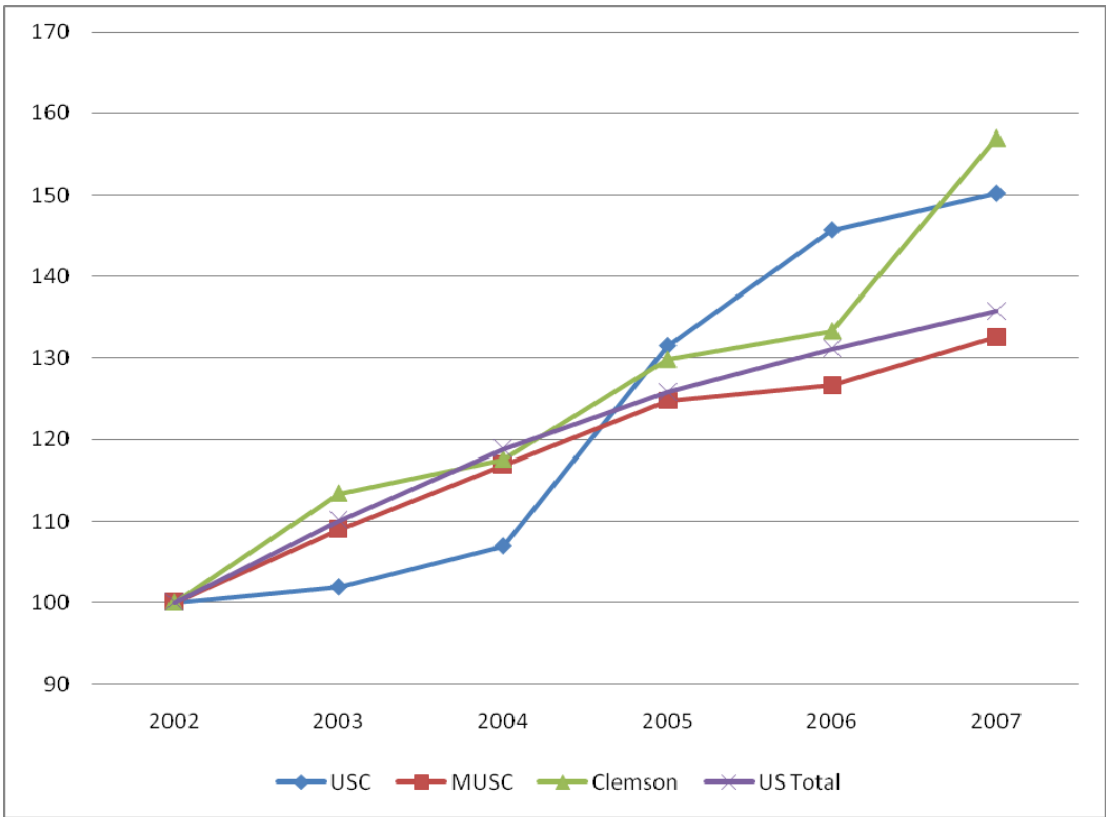


Figure 1: Percent growth in SC university R&D expenditures, 2002-2007, includes government, industrial, and institutional funding. 2002=100. (Source: NSF Survey of R&D Expenditures at Universities and Colleges)

Collaboration among the research universities is a widely recognized program benefit, but it is also quite a new phenomenon. As one CoEE Review Board member remarked, "Collaboration makes competitors into allies." Clemson University, the Medical University of South Carolina, and the University of South Carolina are located in three distinct regions of the state and have research strengths that are complementary but in some cases overlapping. While they do not rank highly as separate institutions – Clemson was 94th, MUSC 96th, and USC 101st in total R&D expenditures in 2006[12] – in 2008 they generated nearly $560 million[13] in research funding collectively. This aggregated funding puts them near the top 20 research institutions in the country, alongside or exceeding prestigious public and private institutions like the University of North Carolina, Texas A&M, UC-Berkeley and Yale.

Health sciences is the field in which collaboration is most evident, and the CoEE in Regenerative Medicine is a powerful example. The three universities are all focusing on the same research theme and worked together to secure the non-state funding match, but their research activities are differentiated and have attracted a variety of private-sector partners. The Regenerative Medicine CoEE is focused on:

[12] National Science Foundation, *Survey of R&D Expenditures at Universities and Colleges, FY 2006.*

[13] Annual university research reports (MUSC, Clemson, USC), August 2008.

- Developing new therapies, medical devices and clinical solutions based on stem cell technologies (MUSC)
- The interaction of chemical and mechanical mechanisms in developmental biology (USC)
- Tissue engineering, biomaterials and implants (Clemson)

The three universities are all active members of the Bioengineering Alliance of South Carolina. The CoEE in Regenerative Medicine is also in discussions with a leading medical device company to leverage the purchasing power of South Carolina in a relationship that could provide substantial recurring CoEE research funds.

A can-do, entrepreneurial attitude has seeped into the institutional culture of the universities and is embedded in department-level tenure and promotion policies decisions. At the University of South Carolina, for example, tenure and promotion decisions include consideration of the faculty member's contributions to commercialization and technology transfer, as well as teaching, publications, and research. This change in mindset will have a long-term impact as junior faculty are hired and promoted and make new research contributions over time.

At all levels, the CoEE program has been a catalyst for the universities to aspire to become "flagship" research institutions working for the benefit of South Carolina. The collaborative spirit manifests itself in symbolic as well as practical ways. MUSC awarded an honorary degree to then-President Andrew Sorensen of USC in April 2008, the first time a South Carolina university has so honored the leader of one of its in-state peers, and will award an honorary degree to President Barker of Clemson in 2009.

Finding #4 - The CoEE program has raised the national and international reputations of the universities and made South Carolina more competitive in the global economy.

In the past South Carolina was not known for having strong research universities, but that reputation has begun to change, thanks in large part to the CoEE program.

- In 2007 the University of South Carolina became a Research University with "very high research activity" according to the Carnegie Foundation, one of 62 public and 31 private universities so classified.
- Clemson University has climbed steadily in the rankings of U.S. public universities, and currently ranks 22nd in the U.S. News and World Report list.
- The Medical University of South Carolina has seen its annual research funding rise from $116 million in 2001 to more than $200 million in 2008.

The national reputations of the universities have risen as the CoEEs build connections to prestigious universities outside South Carolina. For example, the CoEE in Childhood Neurotherapeutics at USC and MUSC has established research relationships with Yale, Johns Hopkins, UNC, University of Colorado, and University of Miami. The Nanostructures in Technology CoEE (USC) collaborates with national and

international partners such as the University of Texas-Austin, Johns Hopkins, The Ohio State University Mathematical Bioscience Program, Leiden University, Purdue, and CNRS, France, to name a few.

Appendix E shows the partnerships that are being forged in South Carolina as a result of the CoEE program. Each of the five Centers in Appendix E has developed a rich network of corporate, academic, government and non-profit partners. The networks are centered in South Carolina but have a broad national and international reach. The result is a positive, catalytic effect on the state's visibility in the global community of corporate and university research. CoEE faculty are being recruited nationally and internationally, and are bringing with them a wealth of personal and professional connections. For example, Dr. Paul Morgan, the Endowed Chair in the Brain Imaging CoEE, came to the University of South Carolina from Nottingham University in England, where he collaborates with Nobel Laureate Sir Peter Mansfield, one of the co-inventors of magnetic resonance imaging. This collaborative research relationship will continue, but Dr. Morgan now resides in South Carolina, not in Nottingham, England.

A number of international companies and organizations have partnered with South Carolina universities. BMW and Michelin are obvious examples at CU-ICAR, but they are just the tip of the iceberg. Smith and Nephew, a UK-based company, cited BMW's positive experience and customer reference as a key reason in its decision to provide the matching funds for the CoEE in Rehabilitation and Reconstruction Science at USC. Other international corporate partnerships and collaborations include:

- Nanostructures in Technology (USC) – companies from Leiden, Grenoble, and Ukraine
- Hydrogen and the Fuel Cell Economy (USC) – Korea, German and Japanese companies
- Solid Oxide Fuel Cells (USC) – Japanese companies
- SeniorSmart (USC, MUSC, Clemson) - Fraunhofer Institute for Software Engineering

The Endowed Chairs program also contributes to South Carolina's national and international image by organizing workshops, training programs and symposia that bring world-renowned academics and business leaders to the state. Examples include the Hollings Cancer Center Symposium on Cancer Drug Discovery/Drug Development; the South Carolina Bioengineering Summit; the International Marine Genomics Workshop; and the Confocal Microscopy Workshop. In March 2009, Columbia will host the annual National Hydrogen Association meeting, which is expected to attract 1,200 attendees from around the world. All of these CoEE-related activities showcase South Carolina to national and global audiences.

The fact that the CoEE program has made South Carolina more competitive in the global economy was evident in a recent meeting with the bond ratings firms in New York. When the bond ratings firms asked about the steps the state is taking to develop an "economic development stimulus-type program" for the global, high-wage economy, the State Treasurer, Converse Chellis, was able to point to the CoEE

program as evidence of South Carolina's progress. "You could tell the reaction to it was very pleasing to them," Chellis said in an interview.[14]

Finding #5 - The CoEE program benefits from strong business and community support, and the industry partners are pleased with the outcomes to date.

Because CoEE research is performed at universities, it is tempting to view the program as "just another" university program. Nothing could be further from the truth. Business leaders were present at the creation of the program in 2002, and business support has been critical to the General Assembly's commitment to the program since then.

The CoEE program is "the life blood of the future of this state," one business leader said during our interviews. "It has been a battle every year to keep it going, but we wouldn't have made any progress as a state without it."

Industry support is evident in the high percentage of private-sector matching funds for the CoEE program (see Figure 2) and the extensive number of industry collaborators with the individual Centers (see Appendices E and F). Companies have provided 30% of the non-state matching funds to date, and have pledged over $35 million in total funding, with large corporations providing the bulk of the participation. Figure 2 also shows the strong support for the program from the philanthropic sector, with 25% of pledged matches to date coming from not-for-profit foundations, and 21% from individual donors. Federal infrastructure funding (17%) and healthcare providers (7%) provide the remainder of the match program wide.

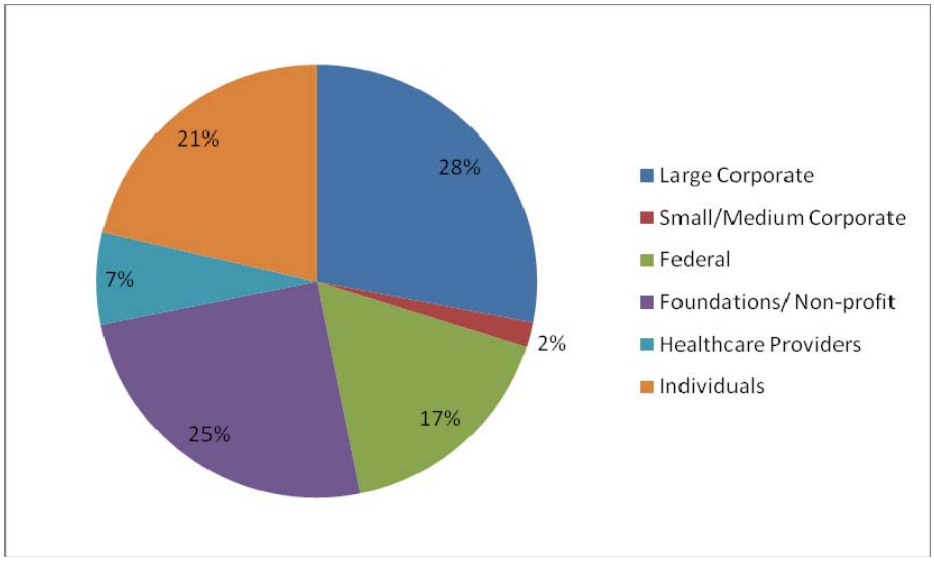


Figure 2: Source of CoEE program match pledges from program inception through FY 2008. Large Corporate refers to companies with over 500 employees. (Source: SC Commission on Higher Education)

[14] David Dykes, "Bond Raters Weigh State's Fiscal Health," *Greenville Online*, September 21, 2008.

This level of corporate funding is remarkable, given that South Carolina is the home of only one Fortune 500 company (SCANA). Companies rarely make endowment gifts to universities the way foundations and individuals do, but more typically provide support for fairly focused and short term contract research, technology licensing, consulting agreements, and small amounts of unrestricted funding for faculty investigators and students.

Similarly, the corporate involvement in the CoEE program has been nothing short of remarkable. Appendix F shows the list of companies with whom the Centers are currently partnered or are in partnership discussions. The names in this list represent a mother lode of economic development opportunity for the state of South Carolina. In addition to the research collaborations with industry that the CoEE program has stimulated, the universities are creating relationships that could open doors for the state agencies that are responsible for attracting new companies to the state.

The participating companies in the CoEE program have expressed a high degree of satisfaction with the program outcomes to date. In the course of our interviews, we did not encounter a single corporate sponsor who was disappointed in the performance or potential of a Center. Many of the companies have based their participation on the promise that the major outcome will be skilled graduates trained in the science and engineering disciplines of the Centers. The utility companies that operate nuclear power facilities in the state were motivated to partner with the Nuclear Science and Energy CoEE at USC by the prospect of a steady supply of nuclear engineering undergraduate and graduate students as potential employees. Fluor cited the Clemson Institute for Supply Chain Optimization and Logistics as one of the reasons for its financial support of the logistics and supply chain management CoEE. At CU-ICAR, BMW funded two Endowed Chairs, and Michelin and Timken each funded one, because of their interests in developing a skilled local workforce in the field of automotive engineering.

Many of the industry partners are also hopeful about the potential for technology transfer of intellectual property resulting from CoEE research for either process improvement or new products and services. Examples here include novel reconstruction and biological regeneration techniques for treating orthopedic damage; clean coal technologies to generate “green” electricity in the state of South Carolina; and diagnostic gene chips.

Finding #6 - The CoEE program has solidified relationships among the universities, hospitals, national laboratories, and industry, and has created a statewide network for innovation.

The CoEE program has enabled the universities to build relationships and consortia with the major hospitals, national laboratories, and industries in South Carolina, and has stimulated the development of a broad-based statewide network for innovation. The degree of cooperation is evidenced in Figure 3, which displays the contribution of various matching sources to the CoEE program. In this figure, each CoEE has been classified by the major industrial sector that it addresses. Appendix C contains the individual CoEE designations to sectors.

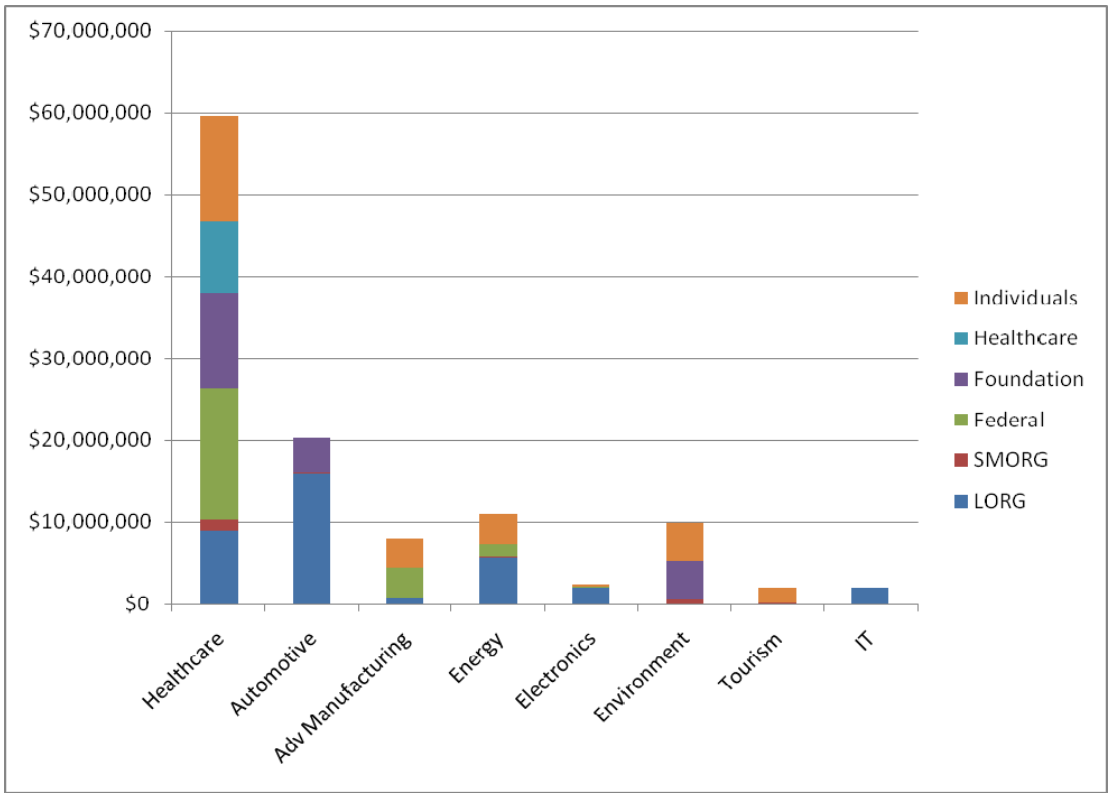


Figure 3: Amount and sources of match pledge by type and CoEE industrial classification from program inception through FY 2008. See Appendix C for industrial sector classifications. (Source: SC Commission on Higher Education)

The chart shows that CoEEs addressing healthcare have assembled a diverse set of participant types in achieving the match when compared to other sectors. As might be expected, the automotive-oriented CoEEs (CU-ICAR) have had the highest proportional support from corporate sponsors. Emerging sectors such as energy and environment rely to a greater extent on philanthropic sources, while the advanced manufacturing sector CoEEs have used a combination of federal resources and individual gifting. These differences in match composition reflect differences in the non-state catchment for the various industrial classifications of the CoEEs.

Health Sciences South Carolina (HSSC) is a striking example of coalition building to support an emergent sector. The universities and the major hospitals created HSSC as a new 501(c)(3) organization to build a statewide platform for translational research, clinical trials support, clinical medicine, and health care quality and effectiveness. HSSC is funded jointly by the universities and the hospitals and integrates all of the health sciences CoEEs. It is the only statewide organization of its kind in the U.S. and has attracted $21 million in funding from the Duke Endowment to date.

South Carolina's innovation network also includes the following key institutions and industry sectors:

- Savannah River National Laboratory
- Nuclear power industry

- Hollings Marine Lab at the Fort Johnson Marine campus
- Textile industry (J.E. Sirrine Foundation)
- Chemical industry (Fuji)

The Savannah River National Laboratory (SRNL) is a key resource in the field of nuclear and alternative energy. Although it is currently managed by Fluor, two-thirds of the Westinghouse engineers remain in South Carolina from the previous management regime. The SRNL is engaged in designing and building four new nuclear reactors and is also committed to developing fuel cell technology. A Hydrogen Fuel Cell Council chaired by President Pastides of USC is working to capitalize on the fact that 80% of the assets needed for developing the fuel cell economy are already in South Carolina.

The CoEE in marine genomics at MUSC has relationships with multiple partners on the Fort Johnson Marine campus, including NOAA, NIST, the College of Charleston, South Carolina Department of Natural Resources, and MUSC. Four hundred people work on this campus, which provides access to exceptional equipment such as a Bruker 800MHz NMR—the only one in the country for marine genomics. The Laboratory is a major resource to CoEE personnel across the state and attracts users to South Carolina from other marine science research centers in the country.

CoEEs are also providing new direction to older industries in South Carolina. Clemson engineers in the Advanced Fiber-Based Materials CoEE are working to develop new organic fiber-based materials for the textile industry. These advanced fiber-based materials are helping to create a new industry focused on high-performance, multi-functional fibers. The military applications include chemical resistance, impact resistance and flame retardant qualities. This program is based on a ten-year NSF Engineering Research Center program and provides retooling and retraining of the workforce.

In agriculture, plant genomic research at Clemson is enabling its traditional regional education-based centers to re-invent themselves as resources for engineered plants for health and nutrition and for improved agricultural production.

In the chemical industry, MUSC is exploring a partnership with Fuji to change the focus of its in-state manufacturing facility from chemical film products to novel medical devices.

As with HSSC, major consortia have been developed for these and other CoEE activities including:

- NSF I/UCRC for Fuel Cells (Industry/University Cooperative Research Center)
- South Carolina Hydrogen and Fuel Cell Alliance - Future Fuels^{TM}
- S.C. Nutrition Research Consortium (Clemson, MUSC, USC, and SCRA)
- COMSET (Center for Materials Science and Engineering Technologies) funded by NSF Partners for Innovation – Photonics Industry

- Individual Chairs have also created industry consortia to coordinate specifically with the activities of their CoEE (for example, Dr. Hubing - Clemson Vehicular Electronics Consortium)

The vertically integrated optoelectronics cluster within COMSET at Clemson includes ongoing research in Photoelectronics, Optophotonics, Cyberinfrastructure, Photonic Materials, and Optical networks. Seventy percent of all photonics-related materials in the United States are fabricated within a 150-mile radius of the Clemson campus. This rapidly-growing industry represents a major economic development opportunity for the state.

Finding #7 – A single, integrated statewide economic development plan does not yet exist in South Carolina, but the CoEE program has coalesced around clusters that could be components of such a plan.

Between 2003 and 2008 the CoEE program has evolved primarily around university priorities and the universities' ability to obtain the non-state funding match. Figure 4 shows the state funds drawn down, from the perspective of the industrial sectors presented earlier (See Appendix C). We see a clear emphasis on the healthcare, automotive and energy sectors, and then a variety of smaller efforts in such sectors as Tourism and Information Technology.

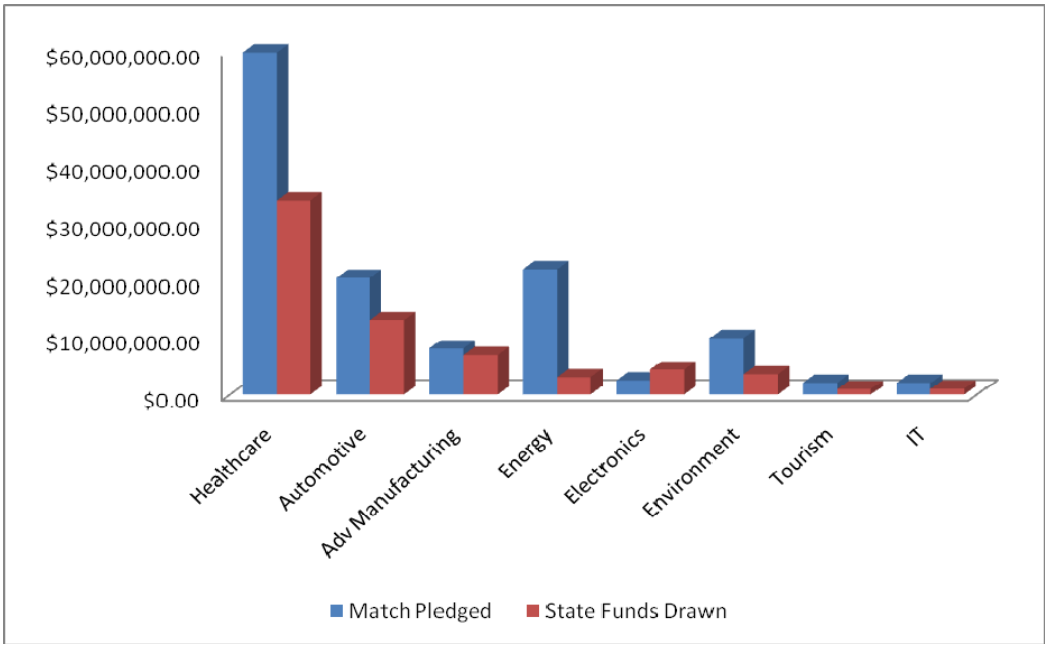


Figure 4: CoEE program center drawdowns from program inception through FY 2008 by industrial sector. See Appendix C for industrial sector classifications. (Source: SC Commission on Higher Education)

This spread is due, in part, because some of the earliest Centers were proposed on an opportunistic basis. Over time, the universities have become more strategic in their submitted proposals and CoEE

planning and have focused their efforts to achieve critical mass in research areas that build on their primary strengths and interests.

Clemson started with a strategy that included eight research and education areas, five of them relevant for economic development. Over time, its CoEE research has become focused in:

- automotive engineering/advanced manufacturing
- advanced materials/photonics
- biomaterials and bioengineering

MUSC started with basic clinical and biomedical sciences, including less mainstream programs such as marine genomics, and is now focused on research-based clinical Centers in disease areas such as:

- neurosciences/stroke
- cancer
- cardiovascular disease

The University of South Carolina has CoEE research clusters focused in the areas of:

- nanotechnology
- energy and environment (future fuels, clean coal, nuclear)
- health sciences

How do these CoEE focus areas fit into South Carolina's economic development plan? The answer is surprising. In 2005, a study by Michael Porter and the Monitor Group entitled, *South Carolina Competitive Initiative: A Strategic Plan for South Carolina* laid out an analysis of four major clusters in the automotive, chemical products, textiles, and travel and tourism fields. Over time, the four clusters grew to eight statewide focus areas:

- Distribution Services
- Apparel
- Automotive
- Recycling (2007)
- Agribusiness
- Nuclear (2007)
- Textiles
- Tourism

Committees and task forces subsequently identified and analyzed 14 regional cluster priorities for the Low Country, Midlands, and Upstate. "Biosciences", "health care" and "medical devices" were defined as regional cluster priorities for the Low Country, Midlands and Upstate, respectively. However, health care is not currently regarded as a statewide economic development priority by the S.C. Department of Commerce. Similarly, manufacturing is not in the list of statewide clusters, but is viewed by the leaders of the General Assembly as a pillar of the state's economy.

The state's Knowledge Economy plan was articulated in a policy letter (July 2008) by the leaders of the General Assembly. It identifies three "Pillars for Success" and assigns responsibility in each sector:

- Manufacturing, distribution and services – S.C. Department of Commerce
- Tourism – S.C. Department of Parks, Recreation and Tourism
- Knowledge Economy – South Carolina Research Authority

Summing up the situation, one former CoEE Review Board member said he is "puzzled that people think the state has an economic development plan." In fact, South Carolina has too many plans and too many groups with different goals and priorities pursuing them.

A major opportunity exists to align the CoEE focus areas with other state programs and incentives, but better coordination is needed. Only when the CoEEs are coordinated with other state programs will the goal of job creation truly come into focus. In the absence of an integrated statewide strategy, CoEE investments will continue to be made primarily based on university research priorities.

Finding #8 - Graduate education is an industry attractor and a workforce and economic benefit of the CoEEs.

Strong companies rely on a well-prepared workforce trained in custom programs designed by top faculty in science and engineering. The CoEE program has spurred the universities to add graduate programs and infrastructure, and to attract quality Masters and PhD students, but more could be done to achieve the full potential of the program in this area.

Students were the only constituency that the WAG team did not meet with during the site visits. Nonetheless, other interviews prompted our general finding that new and innovative graduate education programs will significantly enhance South Carolina's ability to attract new industries and keep well-trained graduates in the state.

Charles Holliday, Jr., Chairman and CEO of Dupont and Chairman of the Council on Competitiveness, and Deborah Wince-Smith, President of the Council on Competitiveness, describe the rationale for developing one-of-a-kind graduate programs:

> "With a billion new workers competing for the world's jobs, simply being an educated American is not an entitlement to a secure, high-wage job. High-speed communications – digitization are commoditizing work processes, making

> it easier – to ship work around the world. American workers must establish a margin of advantage by providing proactive training and education, creating a competitive edge in technical competencies and service industries, developing whole fields of science and new industries, and focusing on creativity, empowerment and entrepreneurship."[15]

The history of the North Carolina Research Triangle Park demonstrates the importance of graduate education. As President Barker of Clemson said, "In manufacturing, there is a one in 10 chance of landing a company if it is lured to the state, but a nine in 10 chance if the product being manufactured comes from knowledge that has been produced in the state."

The CoEE program should seek to determine what graduate degree programs will be equivalent in relevance in 2010 to the computer sciences degree program at UNC that helped lure IBM to Research Triangle Park in 1965.

Other than the graduate program in automotive engineering at CU-ICAR, the undergraduate degree in nuclear engineering at the University of South Carolina is the only new industry-related curriculum of significant scale that the evaluation team identified that is directly related or attributable to the CoEE program, although others that are expanding or just getting underway have great promise.

Finding #9 - The universities have made significant investments in the CoEEs, but they may not be able to invest at the same rate in the future.

The CoEE program started with the idea that the state funding and non-state matching funds would be sufficient to cover 100% of the costs of the program. In fact, the total cost is much greater, and the universities have made significant investments in Center startups, the build-out of research space, and the recruitment of Chairs. While the CoEE program is designed with a target 1:1 state to non-state match requirement, the reality is that the institutions end up investing somewhat more in the Centers than either the state or the match partners, as shown in Figure 5. The universities have provided over $89 million in funding for the Centers. To date, the state has provided $66 million in funding, while non-state match cash contributions have totaled almost $83 million; this gap will close as state draw-downs are authorized based on the non-state matches.

The upfront funding that is needed to recruit and provide the initial salary for top candidates, laboratory build-out, and program startup puts significant demands on university resources early in the CoEE development process, and is "make-or-break" in the recruitment of a first-rate Chair. The power of the CoEE program is the Chair plus the team, yet the total cost of the program is well beyond what is required for the Chair alone.

[15] Charles O. Holliday, Jr. and Deborah L. Wince-Smith "The Game Has Changed . . . the Mission Has Not," *News from the Council on Competitiveness,* Summer 2008, p. 3.

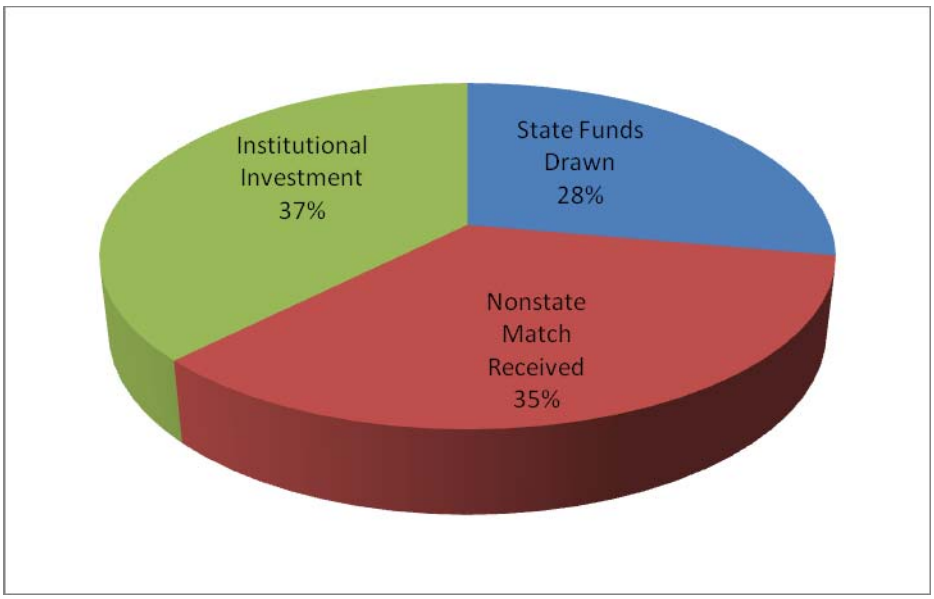


Figure 5: Proportion of sources for CoEE center funding at universities from program inception through FY 2008 (Source: SC Commission on Higher Education, institutions)

In the words of one USC administrator, "We have been starving other programs to make this program work."

Through the end of FY 2008, the universities have funded 37% of the total cost of the program. The university contribution typically goes to the direct costs of developing and operating the Center during the startup period before external research funds are secured. The state funding all goes into the university endowment, where the proceeds generated 1-3 years later provide the long-term stability for CoEEs and Endowed Chairs. In light of the cutbacks in the base level of state funding of higher education, the ability of the universities to continue to be "silent partners" and to invest in new Centers is a critical issue in the program.

Finding #10 - In certain instances, the universities lack the institutional capacity to adequately manage functions and infrastructure associated with the CoEE program.

The evaluation team was impressed by the dedication and professionalism of the university administrators whom we interviewed, but found in several instances that the CoEE program is ahead of the universities' institutional capacity to manage it functionally and physically.

As one Endowed Chair put it, "Everything is great except I have no lab."

The issue appears to be partly one of timing. The CoEE Act was passed in 2002, and the Research University Infrastructure Bond (RUIB) Act – a matching program of $250 million in state dollars to support new research space on the senior research campuses – was passed in 2004. Ensuing delays in

capital projects have put stress on the CoEEs and on the Endowed Chairs who have been hired with promises of space for their research programs, as well as on the partners and companies the Chairs are expected to recruit and initiate.

The issue is of least concern at Clemson, which has generally delayed hiring Chairs until the facilities are ready. (The Clemson endowment three-year payout policy is a helpful factor here.) It is of moderate concern at MUSC, where the Drug Discovery research building is scheduled to open in May 2010 and the Bioengineering research building in March 2011. It is of most concern at USC, where the delay in the completion of Innovista has elevated the costs of new lab space and resulted in unmet expectations among Endowed Chairs and their business partners. Some USC chairs who were promised space in the Horizon building (for university programs) have been told that it will be another year before they can occupy their labs. This has additional consequences when major equipment is transferred from other institutions with the Chair holder. Construction of the Partners' buildings (for private sector companies) promised for completion in 2006 is just starting, and this has ramifications for the economic development goals of the program. For example, one Endowed Chair at USC has the opportunity (and an investor) to start a new company in Columbia. However, there is no space available, which will likely deter the investor.

For the program to continue to recruit top-level individuals, there must be a special effort to assure that the high-level needs of the Endowed Chairs and CoEE Centers can be accommodated, and better pre-planning so that appropriate facilities are ready. For the CoEE program to succeed, university purchasing should not delay or inhibit the acquisition of even trivial items needed for the research, and the university HR function needs to be able to hire new personnel into appropriate job categories without a great deal of bureaucracy.

The universities will not be able to solve these problems alone. The state expects the CoEE program to deliver private-sector outcomes but the universities and the program operate with public-sector rules. The state and the universities need to work together to find solutions and better manage these situations.

Finding #11 - Public awareness of the program is limited, and its image and audiences are not yet well-defined.

The public visibility of the CoEE program is limited, and the general consensus among the stakeholders whom we interviewed is that the program is "undersold and under-promoted," especially when compared to the success that it has achieved. The interviewees expressed the hope and desire that the program would become better known and understood by South Carolina citizens at the grass roots level, by national audiences, and by the Legislature. The key question, however, is "what audiences are critical to CoEE success?"

The main audiences of the public awareness campaign to date appear to have been the general public and the Legislature, to support the annual renewal of the program. The Clare Morris Agency, which is now in the third year of a five-year contract, has the lead responsibility and has helped to define the

CoEE program. When they began their work, the program had no public identity and was described variously as the "Endowed Chairs" program and the "Centers of Economic Excellence" program. The Clare Morris Agency has created and maintains a CoEE program Web site, has developed contact radio spots in the early morning (work traffic time), placed press releases in business magazines, and utilized free press and free media as much as possible. There is no budget for paid advertising.

Using a P.R. firm has exposed the program to the charge that it is using taxpayer dollars to lobby the Legislature. We do not find this charge to be fair. In the 2008-2009 fiscal year, when funding was reduced and subsequently eliminated, the P.R. campaign had no influence on the outcome.

New Carolina has developed the "Research Stars" profiles of the CoEE chairs and has also prepared "a series of writings and conversations to create new energy, new ideas and new jobs in South Carolina." Paper #7, entitled "First-rate Economy or Third World State? It's Up to Us: Protect and Grow the CoEE Program", was authored by Samuel Tenenbaum, a founding father of the program.[16]

The evaluation team believes that a base level of public relations activity is essential for the program, whether this work is done by an outside agency or by CHE in concert with the program stakeholders. Beyond this, the P.R. effort should focus on the core audiences related to state coordination and fundraising from individuals, as discussed in Recommendations #5 and #9.

Finding #12 - The CoEE Review Board has performed effective oversight with support from the Commission on Higher Education.

When the CoEE Review Board first met in October 2002, there was no guarantee that the newly-created program would deliver outstanding results. The fact that it has done so reflects positively on the performance of the Review Board in:

- Financial Oversight – The program has run clean books; the Review Board has been a good financial steward of state resources.
- Adherence to Legislative Intent – The Review Board has made policy decisions in a manner consistent with the enabling legislation.
- Non-Politicization of Board Decisions – The Review Board members are all political appointees, but the state's political leaders have delegated authority and permitted them to govern the program without interference. The Technical and On-Site Panel Reviews have added an important layer of objectivity to Board decisions.
- Program Continuity – Two current Review Board members have been members since 2003. Despite the addition of new members, the program has been managed with continuity. It has benefited from effective support from the Commission on Higher Education and from the university leadership (the university presidents are *ex officio* Board members).

[16] These materials are available at www.newcarolina.org.

The low cost of CoEE program management is also significant and should be mentioned here. Foundations and grant-giving organizations typically spend up to 10% of the value of grants awarded on their own organization. The total cost of CHE staff support, Technical and On-Site Review Panels, and Board meetings, audits, and related organizational expenses has been just $2.2 million over six years, which equates to 1.3% of CoEE awards.

Recommendations

Recommendation #1 - The CoEE program is fulfilling the goals for which it was created, and funding for the program should be continued as a high priority for South Carolina.

By every important measure – jobs created, private-sector support, increased competitiveness, national and international reputation, and cultural and economic transformation – the CoEE program is fulfilling the goals for which it was created. *The key finding and recommendation of the 2003-2008 evaluation team is that funding for the program should be continued as a high priority for South Carolina, that the elimination of CoEE funding in the 2008-09 fiscal year be a one-time event, and that $30 million in annual funding be restored as soon as possible.*

The experiences of other states with programs similar to the CoEE program are instructive here. Michigan, for example, launched its Life Sciences Corridor program with fanfare in 1999 as a 20-year, billion-dollar investment. Funding of $50 million per year was to come from Michigan's share of the tobacco litigation settlement. The Life Sciences Corridor was funded for three years at $50 million but the funding was reduced to $28 million the fourth year due to economic hardship. The next year, under a new Governor, funding was further reduced to $22.5 million, the program was re-named the Technology Tri-Corridor, and the money was split between life sciences, automotive engineering, and homeland security initiatives. Three years later, when the program had lost its momentum and focus, Michigan political leaders realized that university-based economic development was critical to the state's future, reversed course again, and resuscitated the program by securitizing the tobacco settlement money. This restored more than the original level of funding but as a short-term stimulus to the state's economy. The opportunity to benefit from a sustained, long-term investment was lost.

In Georgia, by contrast, the Georgia Research Alliance has operated continuously since 1990 with state funding that has fluctuated between $20 million and $40 million per year.

In terms of future CoEE funding levels, it would certainly be appropriate for the General Assembly to withhold or reduce funding if the universities or the non-state funding match partners are not holding up their end of the bargain. If the percentage of awarded vs. drawn-down funds does not meet a target ratio, for example, the state might restrict the program funding until the fundraising and non-state funding pledges catch up.

Continuous funding, even at reduced levels, is critical to the program's long-term viability, however. It will be very hard for South Carolina to maintain momentum and credibility with non-state matching partners if it suspends the CoEE program funding for an extended period of time. The cost to re-start the program, as Michigan learned, can be greater than the cost to continue funding it at a reduced level. Funding of, for example, $10-15 million per year during the current economic downturn would enable the program to be sustained without serious interruption until such time as the economy improves, when funding could be restored to the original level.

To two questions that arose during the site visits, "When should the program end?" and "What is the appropriate definition of success?", the best answer was provided by one of the interviewees: "When the per capita income of South Carolina [currently at 82%] is at least 100% of the national average."

Recommendation #2 - The program could be more effective if a portfolio approach to CoEE investment were adopted in coordination with other state programs and incentives.

Adopting a portfolio approach to CoEE investments would mean that South Carolina would look at the Centers not on an institutional or individual basis but on what they contribute in the sectors that could be defined as economic drivers for the state. Such a distributional view is shown in Figure 6.

The analysis of CoEE program funding by industry sector shown previously in Figure 3 and Figure 4 provides the backdrop for this recommendation. Figure 6 restates the data in Figure 4 but shows the current CoEE investment portfolio with Advanced Manufacturing, Energy and the Environment, and Health as the three sectors selected for CoEE investment. "Advanced Manufacturing" in this scenario includes automotive engineering as well as enabling technologies in areas such as nanotechnology, advanced materials, and optoelectronics. "Energy and the Environment" includes tourism and marine genomics as well as nuclear energy and hydrogen fuel cells. "Health" includes the CoEEs and Endowed Chairs that are currently organized under the umbrella of Health Sciences South Carolina.

In a sector-based funding approach, a percentage of CoEE funds (for example, 80%) could be allocated to the sectors that the state and the CoEE program have identified as the key drivers in a statewide, integrated economic development plan. The remaining percentage (for example, 20%) could be targeted to emergent technologies or special opportunities – "wild cards", in the words of one university president – that correspond to the strengths of a particular university or interests of a non-state matching donor.

A CoEE portfolio structured in this way would focus funding resources so that the largest share of the investment principal is invested in "blue chips"; i.e. state economic development priorities (including basic sciences related to these priorities), and a smaller share is invested in high-risk/high-return research areas.

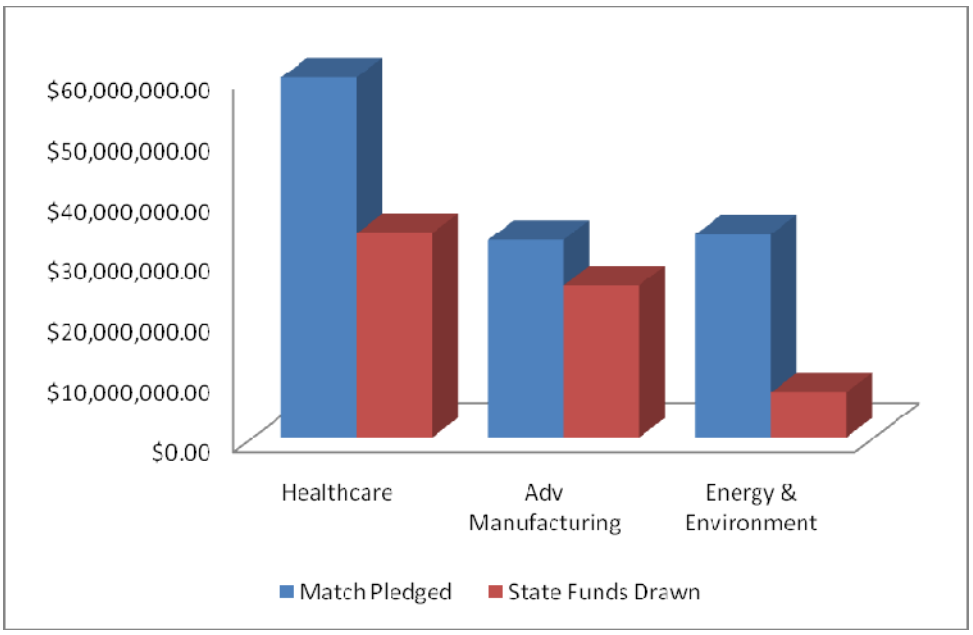


Figure 6: CoEE Program disbursements by aggregated industrial sector through FY 2008 (Source: SC Commission on Higher Education)

The CoEE sectors do not have to be perfectly aligned with the sectors in other state agencies and programs. Health, for example, is unlikely to be a target sector for the S.C. Department of Commerce in the near future. Where the CoEE sectors and the state economic development sectors are aligned, however, funding for the Endowed Chair could become part of the overall recruitment package that the state uses to attract a major company. The CoEE funds would add to the package, and the state could partner with the universities to raise the non-state matching dollars. The value of the CoEE investment would be enhanced as part of a larger package, and the Endowed Chair(s) would be a valuable to link between the state, the company, and the university from the outset.

This approach would help South Carolina to replicate the success of the BMW-Department of Commerce-Clemson partnership at CU-ICAR, and to diversify on a large scale into new industry sectors.

Portfolio-based statewide coordination would also broaden the definition of "job creation" in CoEE proposals by linking the new Center to the jobs in the total recruitment package, and could open the door to a modification of the CoEE match requirement. If state priorities and CoEE priorities are aligned and the economic development benefits are significant enough, the match requirement could be eased or the CoEE program could receive a credit toward the 1-1 match for the universities to use in high-risk/high-return areas where industry funding is not available. Coordination along these lines would increase program flexibility, broaden the base of potential match partners, and help the CoEE program work effectively with major corporations that are not already based in South Carolina.

It would be helpful to include real estate controlled by the universities and the state as part of this coordinated approach. For example, the Dean of Agriculture at Clemson has suggested that the state-owned land adjacent to the research and education centers could be designated as economic

development zones for companies to locate there. The South Carolina Nutritional Consortium could market this opportunity to corporate partners in the agribusiness sector. Each of the Education Center sites could have a unique focus. The Pee Dee Center has become a plant transformation center. The Charleston Center is focused on plant medicine. The Education Centers could become mini-ICARs, with agriculture and nutrition companies clustered around related Clemson and CoEE research activities. State approval and an innovative approach to land use would be needed by the state agencies and by the universities, both of whom control valuable land in different regions of the state.

Recommendation #3 – Front-loaded funding will accelerate new Center startups and the State's return-on-investment. The Review Board should adopt policies to facilitate expedited outcomes.

The CoEE program imposes considerable financial stress on the awardee institutions, especially before the state and non-state matching funds become available. Figure 7 shows the lag in months to getting program fund draw-downs from the state and to chair appointments for CoEEs awarded in 2002-2004. One can see that it can take up to 2 years before the institution sees funding from the state, and up to 5 years to complete funding of the Center. Chair recruitment can take from a few months to as much as 5 years. In many cases the lag in obtaining funding is due to difficulty in achieving the pledge commitments (see Recommendation #4 below). Though these delays are attributable to a number of factors, depending on the circumstances of the particular CoEE, in all cases there are substantial upfront costs associated with launching a Center.

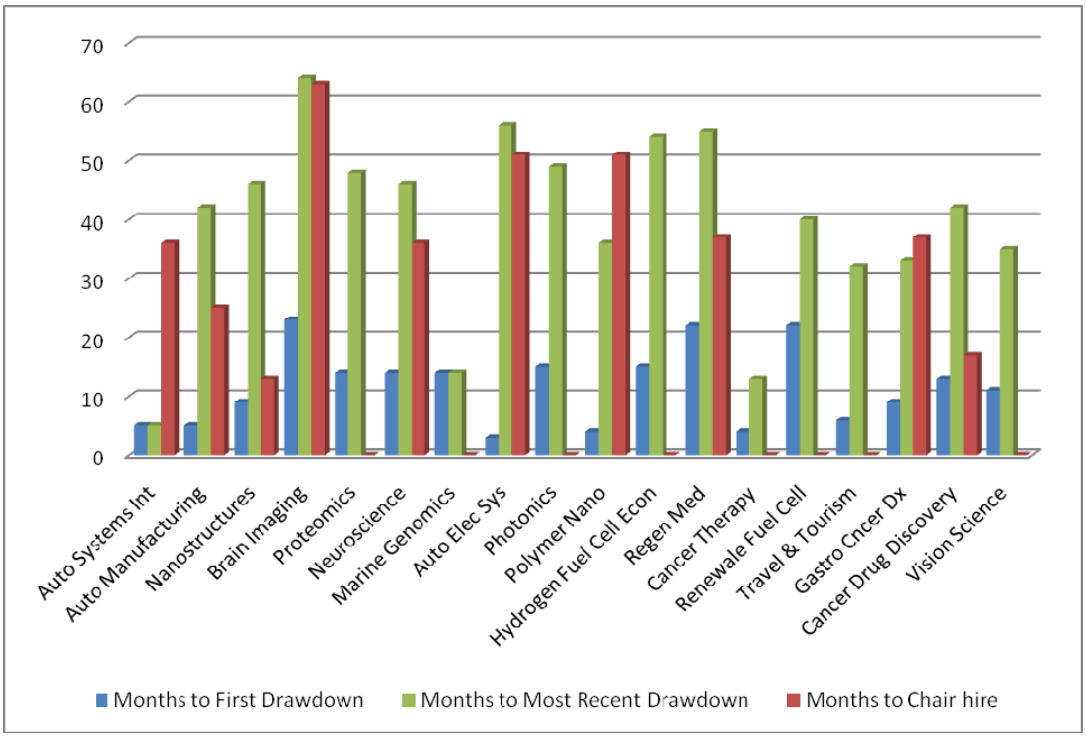


Figure 7: Months to first drawdown, months to most recent drawdown, and months to chair after award for CoEEs awarded 2002-2004 (data through FY 2008) (Source: SC Commision on Higher Education)

To accelerate the state's return-on-investment from Centers that have been awarded but not yet funded, the CoEE Review Board should consider providing programmatic funds for the universities to use immediately post-award for the administrative, infrastructure and recruiting costs associated with launching the Center.

The CoEE legislation would need to be modified in order for the Review Board to take this step. If so, an appropriate time to do this would be during the current fiscal year, when no new CoEE funding is available. This would enable the Review Board to use the accrued interest in the CoEE endowment fund to maintain momentum during the period of no new funding. The front-loaded portion of the state award would not exceed a designated sum (for example, $250,000) and would be made available for Center startup either as a CoEE non-recourse loan or grant, or as a recourse loan based on the university's commitment to re-pay the money when the non-state matching funds become available.

Startup funding is essential for all awarded Centers but is especially critical for Centers that propose pioneering work that still needs to be validated. Most companies provide funds as a bottom-line investment, and to do so they must see downstream value. As a result, fundraising for the match is especially difficult for the most cutting-edge CoEE programs. While potential benefactors may be skeptical of the direction and possible successes of a new Center in such areas, it is precisely these Centers that have the greatest potential for substantial gain in reputation, visibility and outcomes that benefit the program, the institutions, and the state. Cutting-edge research programs are also highly competitive, and South Carolina runs the risk of losing its place as an innovator when there are significant delays.

Implementation of this recommendation in conjunction with Recommendation #4 could result in a more streamlined and effective timeline for new Center development as shown in Figure 8.

Recommendation #4 – The universities should identify potential funding match partners before a CoEE award is made.

The non-state funding match provides important leverage for state dollars and is a litmus test for the economic viability of a proposal, particularly if the match is from the private sector.

The evaluation team found no argument among the universities about the value of the match requirement. It was viewed as making the CoEE program a "stretch" program, as a means of ensuring a university and matching fund commitment to the proposed activity.

But the length of time it takes to realize the non-state match and to draw down the state funds, coupled with the time it takes to recruit the Endowed Chair(s), is far longer than the universities, the CoEE Review Board, and the General Assembly would like.

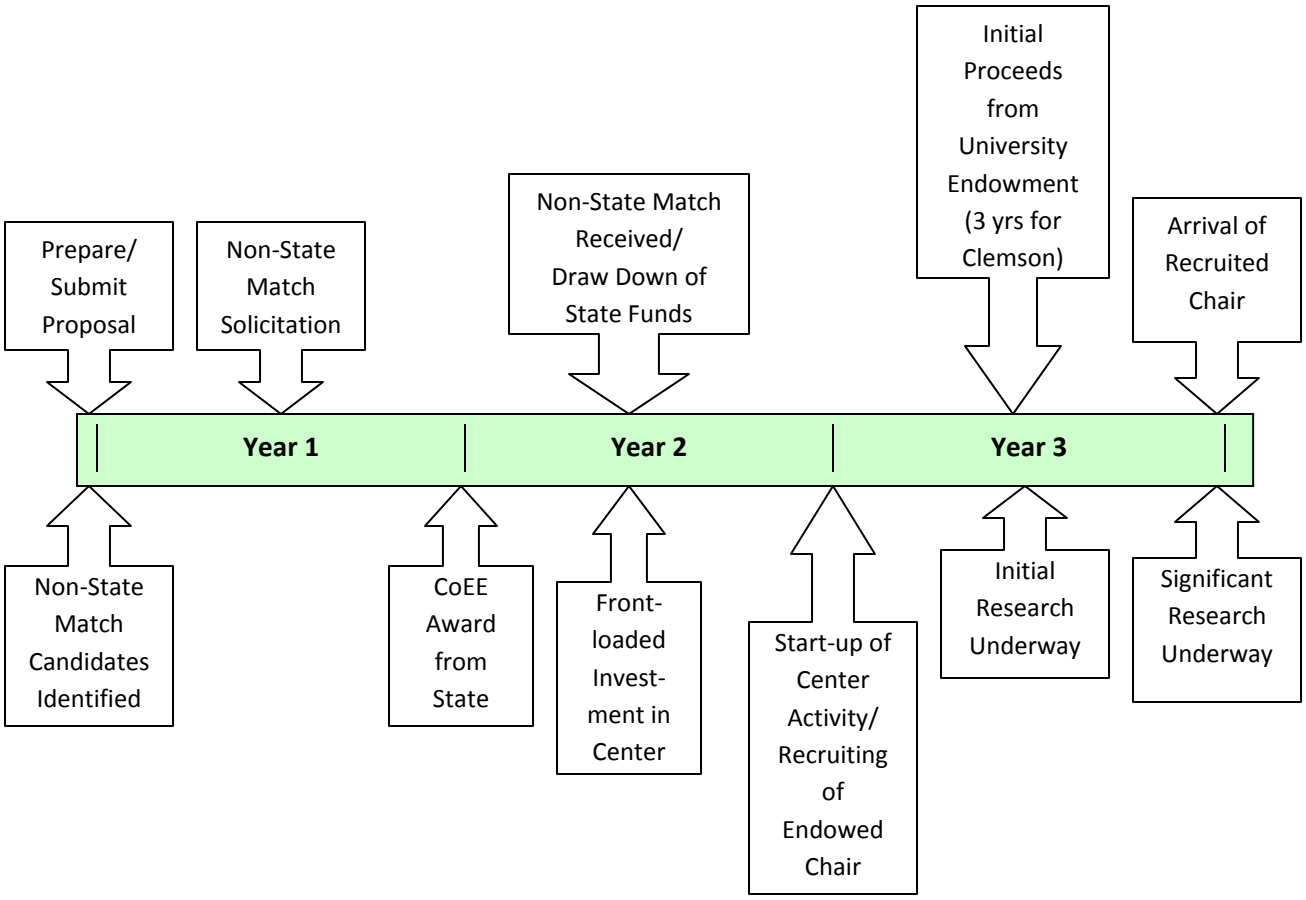


Figure 8. New center development – recommended timeline

In the best-case scenario, the funding match has already been identified at the time the Center is approved and the draw-down of state funds begins immediately, but even then it takes at least one year for the university endowment interest to produce income that can be used to support the new Center. More problematic is the situation where the match is obtained over a protracted period, delaying the Endowed Chair recruitment and the Center startup for as much as five years. During this period other institutions working in the same field can surpass the effort that could be made by the CoEE. The delay is an opportunity cost for the universities and for South Carolina. Even more dire is the situation where the time allowed for the match requirement runs out with only a fraction of the match remaining to be identified, and the state award has to be terminated. In this situation, both the scientific opportunity and the funding in hand are lost.

Clemson University's College of Engineering and Science has established a policy that requires the non-state pledge to be identified before the CoEE proposal is submitted. This is part of the College's strategy to establish a well-functioning Center into which the Endowed Chair can be inserted. The recruited candidates can integrate into the ongoing activity and add value to it to become successful. This approach is more likely to ensure that the chair will stay at the university and put down roots in South

Carolina. Such a strategy can also preserve the activity of a proposed Center in the unfortunate circumstance where the match is not completed.

We recommend that the Review Board encourage the universities to have the non-state match partner identified before a CoEE award is made.

It is important to avoid a situation where money drives the decision, so this recommendation should be coupled with the CoEE award criteria that also give equal weight to the scientific and technical merit of proposals and the economic development potential of the proposed Center.

Recommendation #5 - The universities could explore creative approaches to fundraising that also enhance program outreach and visibility.

The universities should explore new approaches to fundraising, including working with individual donors in non-traditional ways that increase the visibility of the CoEE program.

The burden of fundraising currently appears to fall on the Principal Investigators of new Centers, with support from the Development Office and university leadership. The pool of potential in-state corporate contributors is smaller today than it was when the program began. Many of the companies with large in-state operations – BMW, Michelin, Timken, Santee Cooper, Fluor, etc. – have already pledged or given significant sums.

Individual donors are a constituency where MUSC, in particular, has experienced success. MUSC has organized Advisory Boards comprised of community leaders and influential citizens around specific diseases and health issues, in part as a means of reaching out to prospective donors. Individual donors are pleased to have their gifts matched by the state, and in the case of large gifts the donor may get to name the Endowed Chair.

Clemson and the University of South Carolina, which have large numbers of loyal alumni, could adapt this strategy using the power of small donations in large numbers. USC has over 230,000 living alumni (180,000 from its Columbia campus alone), and Clemson has over 120,000. Individual donations of $25 per year from 10,000 alumni would generate recurring revenue of $250,000 that the university could use as a discretionary CoEE resource to cover, for example, new Center startup costs. Upping the contributed amount per alumnus to $100 per year would result in $1 million in recurring revenue, a non-state match sufficient to endow a $10 million Center over five years. One former Review Board member suggested that the individual donation could be added to the cost of a season football ticket. The idea could be applied to any number of sports activities and university and alumni events, or a targeted campaign for the CoEEs could be created.

Individual donor outreach would markedly increase the visibility of the CoEE program and public awareness of its goals and achievements. It would establish a personal link between the alumni and the program, strengthen the program's funding base, and add a unique new dimension to the university's bonds with its graduates.

Recommendation #6 - The program should increase the focus and emphasis on graduate education as a stimulus for developing a high-tech workforce in South Carolina.

Graduate students are the fuel for innovation within the CoEEs, and a highly-trained workforce with local roots is critical to the future success of South Carolina industry. The availability of a skilled workforce and trained students who will stay in South Carolina was the most often mentioned benefit of CoEEs by private-sector match partners. Students are the most effective means of technology transfer and an important resource for university start-up companies.

The Review Board should consider supporting graduate students and graduate education as part of the decision to fund new Endowed Chairs and CoEEs. This is consistent with the On-Site Review Panel recommendation, which noted the current lack of emphasis on graduate education and graduate programs in the CoEE proposals that are submitted for funding.[17]

We recommend that the Review Board add "graduate education" as a check-off box in the review criteria for submitted proposals. The universities are likely to respond in substantive and creative ways.

Providing funding for graduate students could also help address this issue. As with Recommendation #3, this would require that the General Assembly implement the proposed Section 120 (on Programmatic Support) to permit accrued interest in the CoEE Matching Endowment to be used for program-related purposes approved by the Review Board. CoEE graduate fellowships would help South Carolina attract out-of-state students with exceptional credentials, mirroring the strategy of recruiting Endowed Chairs but at a younger age. Industry is already providing some graduate fellowship support. An annual supplement of $8,000-$12,000 as a CoEE match to the industry fellowships, or full stipends of $25,000-$30,000, would be highly desirable.

The task of developing new graduate programs tied to the emerging needs of industry is larger and more complicated. A critical mass of faculty is needed to launch a new graduate program. The automotive engineering program at CU-ICAR, for example, has four Endowed Chairs and six junior faculty, and $36 million in state and non-state matching funds has been invested, not including the construction cost of the Campbell Graduate Engineering Center building. An in-depth study of existing graduate courses and programs, mapped to a statewide economic and workforce development plan, is needed to address this issue. There are significant costs involved in starting a new program, and the South Carolina universities have complementary strengths, so this should be done inter-institutionally, not at each university individually. South Carolina could also explore out-of-state graduate education partnership opportunities in critical areas where in-state strengths are not sufficient; for example, with Vanderbilt University in medical informatics, or with Carnegie Mellon in computer sciences. A number of research and graduate curriculum initiatives along these lines appear to be already underway.

[17] South Carolina Centers of Economic Excellence, *Minutes of the Review Board Meeting,* June 18, 2007, p. 10.

Recommendation #7 - A new statewide approach to technology transfer would help commercialize CoEE results.

The technology transfer offices at the three universities coordinate their activities well, and commercialization results have improved in recent years due to the CoEE program and to the increased emphasis that the universities have placed on research and economic development generally. Figures 9 through 11 show the patent disclosures and technology licenses at the universities 2002-2008. These charts show the transformation at the universities toward more entrepreneurial activity over the last 6 years.

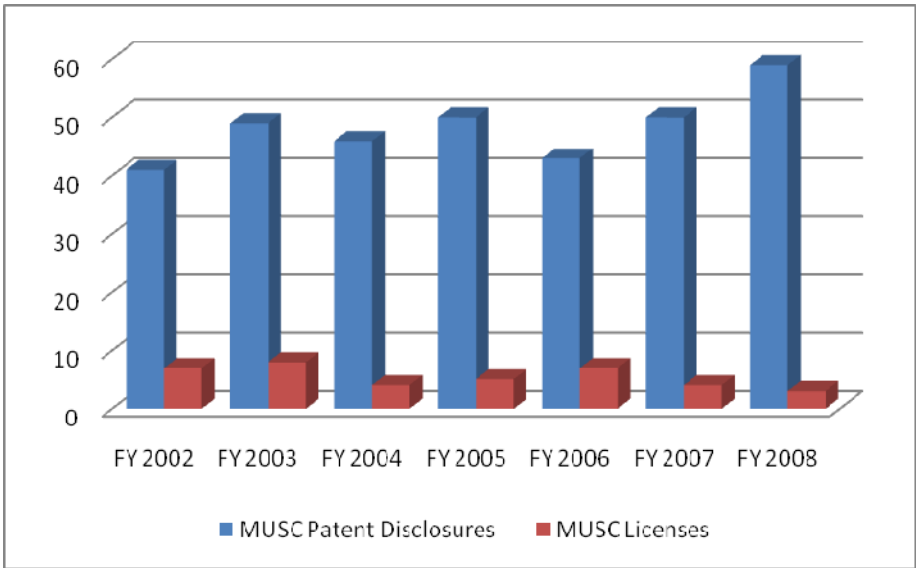


Figure 9. Medical University of South Carolina patent disclosures and technology licenses, 2002-2008 (Source: MUSC)

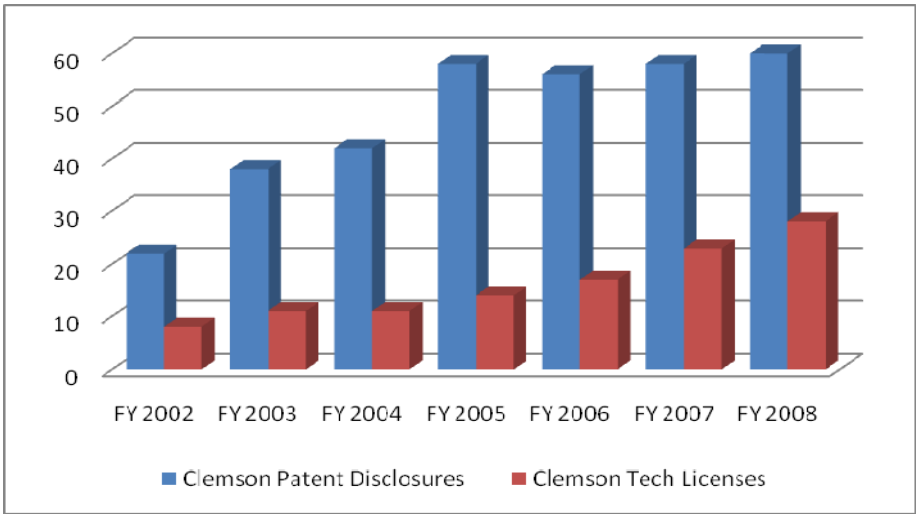


Figure 10. Clemson patent disclosures and technology licenses, 2002-2008 (Source: Clemson University)

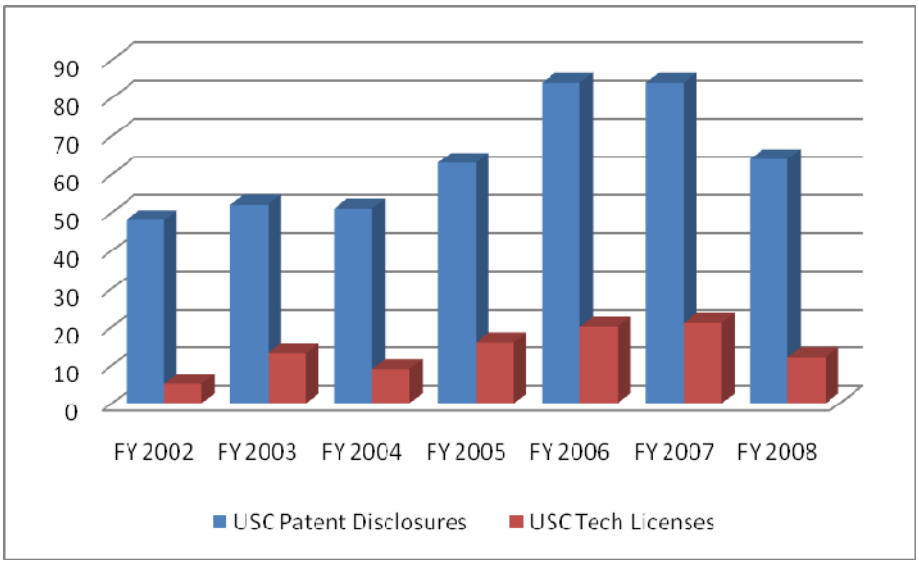


Figure 11. University of South Carolina patent disclosures and technology licenses, 2002-2008 (Source: University of South Carolina)

The universities could develop a Web-based statewide portal to promote the licensing activity and technology assets of the three institutions, but we did not find that any particular benefit would result from combining the technology transfer functions and activities in a single office.

The technology transfer offices are set up to secure and license university technologies and to facilitate startup companies and commercialize research results in a timely manner, but it is not clear that they should have the lead responsibility for meeting the state-mandated requirements of the CoEE program to focus on economic development. The CoEE faculty expressed concerns that the offices are too slow and too committed to following "rules" rather than embracing a goal of success with acceptable risk. The university technology transfer function was described by the words: "Control – Manage – Restrict."

In fairness, this description is not unique to South Carolina, but fits most university technology transfer offices in the eyes of faculty. We recommend that South Carolina consider the formation of a technology transfer function specifically to help the CoEEs spin off companies, perhaps taking advantage of an existing organization such as SCRA and the SCLaunch program. This entity would provide a one-stop resource for academic entrepreneurs with respect to business planning, prototyping, and start-up funding. It would coordinate closely with the technology transfer offices, which would continue to have the primary responsibility for intellectual property and licensing, but would speed up the commercialization process, make it more business-like, and instill a perception in the business community that they are dealing with another business entity, not a university.

The Georgia Research Alliance VentureLab program provides a model for South Carolina in this area (see Appendix B). South Carolina could create a new entity outside the university that could involve, for example, the creation of a for-profit holding company of LLCs for CoEE research. If the VentureLab model were emulated, the creation and management of this entity would not be a financial cost to the universities. SCRA would play the GRA role and provide bridge funds to develop the commercial idea

and sustain the business development activity up to the LLC-creation round of funding and the initial round of third-party funding for the start-up companies as they exit from the LLC holding company. This kind of commercialization activity would not be a formal responsibility of the CoEE program (and a review of the SCLaunch program was not part of the CoEE program evaluation), but it would increase the state's return-on-investment and stimulate the technology transfer function.

Recommendation #8 - Regulatory relief is needed to address issues of university services and infrastructure.

The WAG team has not done an in-depth analysis of the state rules and regulations that govern the approval process for new university buildings and construction. We did hear concerns, however, that the total cost of CoEE-related projects has increased significantly due to delays and state oversight that the universities view as restrictive and unnecessary. The high expectations associated with the CoEE program require an additional level of facilitation.

In this regard, the regulatory relief from some of the state-imposed regulations on university operations requested by the three research university presidents should be supported by the state's business community and acted on by the General Assembly as soon as possible.

Recommendation #9 - The CoEE program should establish a Council of Chairs and an annual CoEE conference.

The Endowed Chairs are a "Brain Trust" for South Carolina and should be called on to provide state leadership in matters of science and technology. To stimulate this activity, we recommend that the program establish a Council of Chairs that would meet at least annually. We also recommend that the program organize an annual conference with 150 or so key opinion leaders from government, industry, and the universities. This Mackinac Island or Davos-like event would:

- Allow the Chairs to meet in person with the state's business and political leaders
- Enable all of the state stakeholders to discuss future R&D goals and priorities for South Carolina
- Publicize CoEE research, inventions and discoveries
- Develop and articulate strategic goals for higher education and the state's economy for consideration by the Governor and the Legislature

The invitees could include, for example, the individuals who worked together on the follow-ups to the recent Porter/Monitor Group report. Selected out-of-state invitees could also be included. The Council of Chairs meeting and Annual CoEE Conference could be held on a rotating basis in different regions of the state, or in one location. The event costs would be paid by a corporate sponsor and/or the attendees, not by the Review Board. Other ideas for engaging the chairs in statewide activities should also be pursued.

Recommendation #10 - The program should establish future performance metrics and streamline reporting.

Future evaluations of the CoEE program should focus not only on the success of individual centers, but also on the recognition that this is a statewide program that should be evaluated by its aggregate performance, much as one would evaluate a diversified stock portfolio. Measures such as technology employment, patents and licenses, new company formation, venture capital investment, degrees awarded, and R&D as a percent of state GDP are all relevant as statewide measures of CoEE performance, as well as potentially attributable to particular CoEE sectors (e.g., Advanced Manufacturing, Energy and the Environment, or Health as shown in Figure 6).

There appears to be a disconnect between the Review Board, the CHE staff, and the CoEE faculty and university leadership regarding the current reporting requirements. The universities described the bureaucracy of the program with "respectful discontent," indicating that the reporting by Endowed Chairs, Principal Investigators, and administrators has increased in volume and frequency, requiring them to prepare highly detailed, often redundant reports. The Review Board and CHE staff, on the other hand, do not view the reporting requirements as onerous.

Until very recently, the program provided no resources for the universities to manage the reporting requirements. Even with financial support, the reporting requirements should be reviewed and, where possible, streamlined. The program has added a new layer on top of existing university reporting requirements, and the problem is exacerbated by data requests that are occasionally made by the Legislature and the Governor's Office and by evaluation groups such as this one. The universities have expressed a willingness to meet with CHE staff to determine what can be done to eliminate redundancy and minimize the administrative burden.

Additional recommendations

1. Enhance On-Site Panel Review

The evaluation team found that the on-site review panel is working effectively, but the process could be enhanced by including one or two reviewers who live and work in South Carolina and who are familiar with the state's profile and economic development prospects, provided they also are knowledgeable about how universities work. Implementation of this recommendation should be done in coordination with Recommendation #2 above.

2. Clarification of Chair Recruitment Policy

The CoEE Program Guidelines permit the hiring of Endowed Chairs from within the institution, but as a matter of practice there appears to be a tacit policy that the Endowed Chairs come from out-of-state. All of the Endowed Chairs recruited to date have been new hires. In a few cases, the bias toward out-of-state candidates could slow the development of a new Center and/or result in the loss of a highly-valued, equally-qualified, faculty member already in place. Some flexibility is desirable, wherein, for example, an in-state candidate could become an Endowed Chair without a national search, based upon

the nomination of the University President and subject to the approval of the Review Board. This would permit the senior research universities, for example, to propose a new Center in a target sector based on the expertise and qualifications of a current faculty member, or to retain an emerging faculty "star" who would otherwise leave the state.

3. Policies for Modifying and for Sunsetting Centers

Situations will occur, both when Centers are starting or after they have been established, where they need to be modified, updated or eliminated. It would be advantageous to have program guidelines in place to facilitate these changes consistently across CoEEs. Issues to be considered include:

- Preservation of a new Center that achieves, for example, 80% of its non-state match by allowing it to draw down CoEE endowment funds, subject to a second review and positive recommendation from the On-Site Review Panel.
- Requiring a Center seeking to substantially modify the focus of its research to re-submit its proposal, even when 100% of the matching funds have been raised.
- A clear understanding of what happens when an Endowed Chair retires, dies, or is recruited elsewhere; or when a Center is no longer scientifically or economically relevant. Does the university keep the money and re-deploy it at its own discretion? The stipulation that, for "terminated" Centers, the money should be returned to the CoEE endowment, should be clarified.
- A clear understanding of when the oversight responsibilities of the Review Board end for Centers; i.e. when/if a Center "graduates" from the CoEE program.

Conclusion

The evaluation team has found that in the first six years of its existence the CoEE program has had a profound and positive impact on the prospects for economic growth and diversification in the State of South Carolina. It has raised the quality and relevancy of university research, improved the stature of the research universities, and increased collaboration among the universities and between the universities and the private sector. Economic impacts in terms of increased external funding, new job creation, and business location decisions have been significant and can be expected to grow as the program continues and matures.

In the Fall of 2008, there was a significant deterioration in the national and state economy, and the prospects for continued program funding at $30 million annually, which had seemed assured just a few months earlier, dimmed. The $10 million in CoEE funding for the 2008-2009 fiscal year was cut, the senior research universities took a 15% reduction in General Fund appropriations and faced the prospect of additional cutbacks, and the outlook for continued state investment in the CoEE program and in higher education became uncertain.

At the same time, the value of the CoEE program and of South Carolina's Knowledge Economy investments received strong validation in the *State New Economy Index,*[18] published in November 2008. The *State New Economy Index* ranks all 50 states according to 29 indicators, grouped into five categories: knowledge jobs, globalization, economic dynamism, transformation to a digital economy and technological innovation capacity. The trends for South Carolina are as follows:

- South Carolina has moved in the overall scoring from being 39th in the nation in 2007 to holding the 34th slot this year
- South Carolina ranks in the top six states for two indicators: Foreign Direct Investment and Movement Toward a Green Economy
- South Carolina is among the top five movers from 2002 to 2008 for the following indicators:
  - Scientists and Engineers, from 44th to 35th
  - Industry Investment in R & D, from 36th to 28th
  - Export Focus of Manufacturing and Services, from 29th to 17th
- South Carolina is among the top five movers from 2007 to 2008 for the indicator of Immigration of Knowledge Workers, from 36th to 25th

While it is not possible to assign a direct cause-effect relationship between the CoEE program and all of these positive trends, the CoEE program has clearly been a contributing factor, particularly in the "Scientists and Engineers" and "Immigration of Knowledge Workers" categories. This achievement should be lauded, not overlooked. The CoEE program is the centerpiece of the state's investment in the Knowledge Economy. As shown in Figure 12, "CoEE Investments and Jobs Flow," it has enabled the state to recruit people and develop programs that will continue to bring new resources (business, people, federal and private funds) and pay dividends to South Carolina long into the future.

As the General Assembly prioritizes the demands for state funding and the uses of South Carolina Education Lottery proceeds, the evaluation team encourages it to recognize the potent stimulus effect and long-term economic benefits of the CoEE program, and to continue supporting it.

During the 2008-2009 fiscal year, in which there will be no new funding for the program, we recommend that the General Assembly implement the proposed Section 120 (on Programmatic Support) to permit the Review Board to use the accrued interest in the CoEE Matching Endowment for program-related purposes approved by the Review Board.

[18] Robert D. Atkinson and Scott Andes, *The 2008 State New Economy Index: Benchmarking Economic Transformation in the States* (The Information Technology and Innovation Foundation, November 2008) at http://www.itif.org/index.php?id=200.

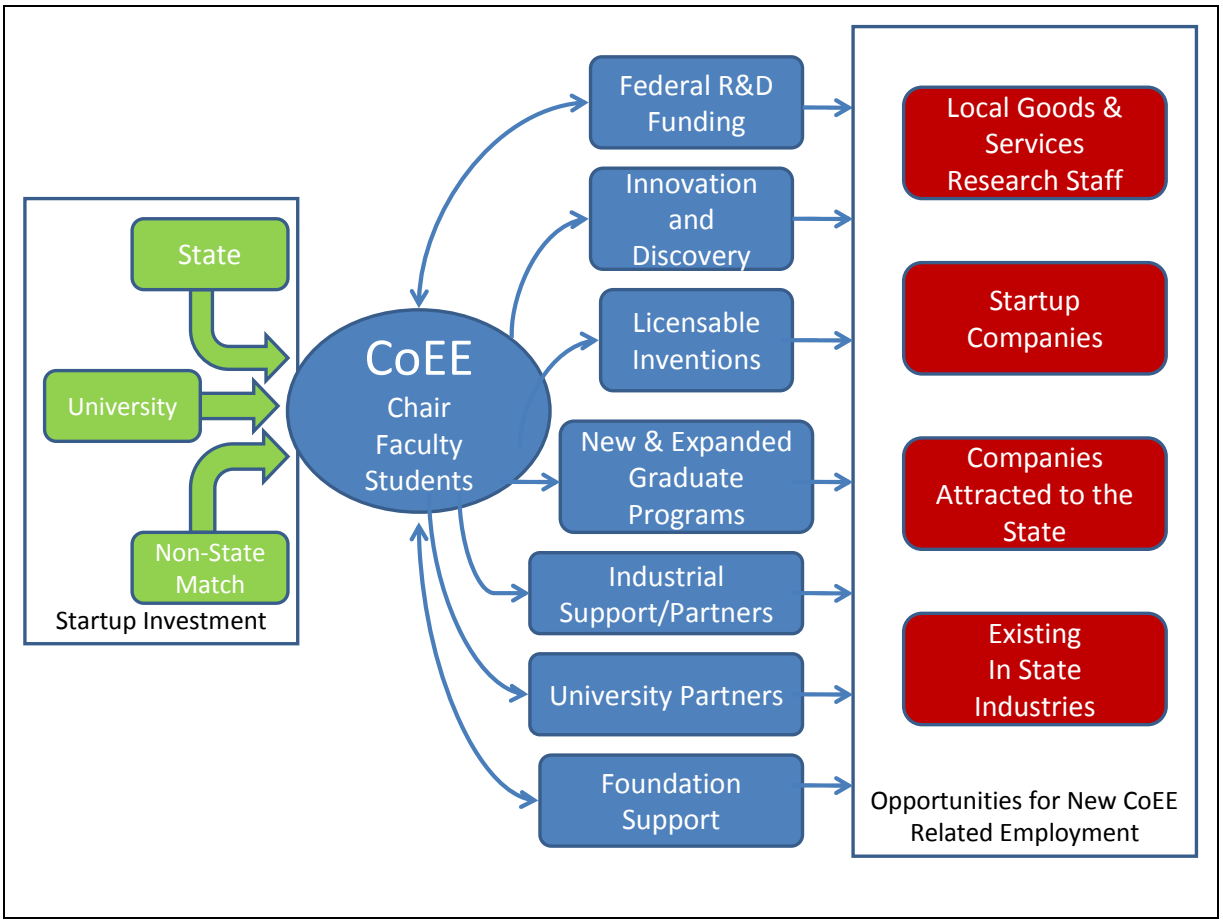


Figure 12. CoEE Investment and Jobs Flow

Consistent with Recommendations #1 and #3 above, this would enable the Review Board and the senior research universities to make targeted investments that will accelerate the development of new Centers that have been awarded. This would help the CoEE program maintain momentum in a difficult financial year and enable the state to realize a return more quickly on the CoEE investments that it has already made.

The CoEE program represents an extraordinary effort by South Carolina to invest in its economic future. In the course of performing our evaluation, we identified a number of actions that could improve the program's effectiveness and economic impact. Our overall conclusion is that the CoEE program is a best-in-kind program that is, or should be, the envy of other states. South Carolina and its research universities are to be applauded for developing and nurturing the CoEE program as a powerful tool in the improvement in the quality of life of citizens, the development of a Knowledge Economy, and the creation of high-wage jobs.

Appendix A

List of Persons Interviewed Over the Course of the Project

KEY:

CHE	*South Carolina Commission on Higher Education*
Clemson	*Clemson University*
CU-ICAR	*Clemson University International Center for Automotive Research*
MUSC	*Medical University of South Carolina*
PI	*Principal Investigator*
SC CoEE	*South Carolina Centers of Economic Excellence*
USC	*University of South Carolina*

Dr. Albert G. Abbott, Interim Chair, Genetics & Biochemistry, Co-PI for Molecular Nutrition CoEE, Clemson
Dr. Robert Adams, CoEE Endowed Chair, Stroke, MUSC
Dr. Lawrence Allen, Dean, College of Health, Education, and Human Development, Clemson
Dr. David Allison, PI for Health Facilities Design and Testing CoEE, Clemson
Ms. Rita Allison, CHE Communications Director
Dr. Michael Amiridis, Dean of Engineering and PI for Strategic Approaches to Electricity Production from Coal, USC
Dr. Argentini Anderson, CHE Program Manager, CoEE Team
Mr. Tom Anderson, Chief Executive Officer, MUSC Foundation
Mr. Ingo Angermeier, President, Spartanburg Regional Medical Center
Dr. John M. Arthur, PI for CoEE in Renal Biomarkers, MUSC
Dr. Gary Aston-Jones, CoEE Endowed Chair, Neuroscience, MUSC

Dr. John Ballato, Director of COMSET, PI for Photonics Material
Dr. Susan Barefoot, Assoc Dean, PI for Molecular Nutrition CoEE, Clemson
President Jim Barker, Clemson University
Dr. Gordon Baylis, PI for Brain Imaging CoEE, USC
Dr. Abdel Bayoumi, Co-PI for Nuclear Science and Energy CoEE, USC
Dr. Yaroslaw Bazaliy, Associate Faculty for CoEE in Nanostructures, NanoCenter, USC
Dr. Mark Becker, Provost, USC
Ms. Laura Belcher, CHE Program Coordinator, CoEE Team
Dr. Brian Benicewicz, CoEE Endowed Chair of Polymer Nanocomposites, NanoCenter, USC
Mrs. Paula Harper Bethea, CoEE Review Board Chair
Mr. Arik Bjorn, CHE Information Specialist/Archivist, CoEE Team
Dr. Rosemarie Booze, Interim Vice President for Research, Office of Research and Economic Development and PI for Childhood Neurotherapeutics, USC
Mr. James R. Bottum, Vice Provost and CIO, PI for CoEE in Cyber Institute, Clemson
Mr. Jim Brogdon, Senior Vice President, Santee Cooper
Dr. Johnell Brooks, Asst. Professor of Psychology, Co-Project Director for SeniorSMART CoEE, Clemson
Mr. Austin Byrd, Smith & Nephew
Mr. Steve Byrne, Senior VP, South Carolina Electric and Gas, CoEE Industry Supporter

Ms. Julie Carullo, CHE Director of Governmental Affairs and Special Projects
Dr. Thomas Chandler, Co-PI for Nanoenvironmental Research and Risk Assessment CoEE, USC
Dr. Frank Chen, Associate Faculty, CoEE in Solid Oxide Fuel Cells, USC
Dr. Marc Chimowitz, CoEE Endowed Chair, Neuroscience, MUSC
Ms. Kathy Coleman, Director of State Relations, Office of Government Affairs, Clemson
The Honorable Dan Cooper, SC House of Representatives, Chairman, House Ways & Means Committee
Mr. Mike Couick, CEO of Electric Cooperatives of South Carolina, Inc.
Mr. Warren Counts, Derrick, Stubbs, & Stith, CoEE Contracted Auditor
Dr. Mas Crawford, Associate Faculty for CoEE in Nanostructures, NanoCenter, USC
Dr. Scott Crittenden, Associate Faculty for CoEE in Nanostructures, NanoCenter, USC
Dr. Christine W. Curtis, Vice Provost for Faculty Development, USC

Mr. Brett Dalton, Chief Financial Officer, Clemson
Ms. Jessica Daly, Clare Morris Agency, CoEE Contracted Marketing Agency
Dr. Darren M. Dawson, Dept. Chair of Electrical and Computer Engineering, PI for Optoelectronics CoEE, Clemson
Dr. Don DiPette, Dean, School of Medicine, USC
Dr. Joseph T. DiPiro, Pharm.D., Executive Dean, South Carolina College of Pharmacy, MUSC
Dr. Larry Dooley, Associate Dean of Research, College of Engineering and Science, Clemson
Dr. Larry Durstine, Chair, Department of Exercise Science and Co-PI for Rehabilitation and Reconstruction CoEE, USC
Dr. Cheryl Dye, Assoc Professor of Public Health Sciences, Co-Project Director for SeniorSMART CoEE, Clemson

Prof Chip Egan, Interim Dean, College of Architecture, Arts & Humanities, Clemson
Dr. Paul Eleazer, PI for SeniorSMART, USC
Mr. Scott English, Chief of Staff, Governor Mark Sanford

Dr. John Feussner, M.D., M.P.H., Chair, Department of Medicine, MUSC
Mr. Jim Fisher, VP for Development, MUSC
Mr. George Fletcher, Executive Director of SC's Council on Competitiveness
Ms. Robyn Frampton, Chief Financial Officer, MUSC Foundation

Dr. Sebastiano Gattoni-Celli, Chief Executive Officer, SemiAlloGen
Dr. Jill Gemmill, Executive Director, Cyberinfrastructure Technologies, Co-PI for Cyber-Institute CoEE, Clemson
Dr. Mark S. George, Director, Center for Advanced Imaging Research (CAIR), MUSC
Mr. Gary Glenn, CHE Finance, Facilities, MIS Director
Mr. Lyles Glenn, CoEE Review Board member
Dr. Michael R. Gold, M.D., Ph.D., Director, Division of Cardiology, MUSC
Dr. Anand K. Gramopadhye, Dept. Chair, Industrial Engineering, PI for Supply Chain CoEE, Clemson
Dr. Ray Greenberg, President, MUSC
Mr. David Grigsby, Senior Vice Provost for Academic Affairs (CoEE Administration), Clemson
Dr. Esin Gulari, Dean, College of Engineering and Science, Clemson

Dr. Imtiaz Hague, Chair, Dept. of Mechanical Engineering, Clemson
Ms. Davy Hammatt, Development Manager, Clemson
Mr. Chad Hardaway, Associate Director, Innovista

The Honorable Robert Harrell, Speaker of the House, SC House of Representatives
Dr. Kathy Headly, Assoc Dean for Research, College of Health, Education, and Human Development, Clemson
Dr. Doris Helms, Provost, Clemson
Mr. Bobby Hitt, PR Director for BMW and CoEE Review Board member
Mr. Chip Hood, Executive Director for the MUSC Foundation for Research Development, MUSC
Mr. David Howerton, Michelin
Dr. Todd Hubing, CoEE Endowed Chair in Electronic Systems Integration, CU-ICAR
Ms. Wanda Hutto, CoEE Project Manager
Mr. Gary Hyman, CEO, Orthopaedic Research Foundation of the Carolinas

Dr. Peter W. Kalivas, Ph.D., Research Chair, Department of Neurosciences, MUSC
Dr. Arnold Karig, MUSC Campus Dean of SC College of Pharmacy, MUSC
Dr. John W. Kelly, VP for Public Service & Agriculture, PI for Urban Ecology CoEE, Clemson
Dr. Jamil Khan, Dept. Chair, Mechanical Engineering and PI Nuclear Science and Energy CoEE, USC
Dr. Sheryl Kline, Interim Dean, Hospitality, Retail and Sport Management/ PI for Travel and Tourism CoEE, USC
Dr. Dan Knapp, PI for CoEE in Proteomics, Clemson
Dr. Travis Knight, PI for Nuclear Science and Energy CoEE, USC
Dr. Thomas Kurfess, CU-ICAR Endowed Chair in Automotive Manufacturing

Dr. Martine LaBerge, Co-PI Regenerative Medicine, Dept Chair, Bioengineering
Ms. Pamela Lackey, CoEE Review Board member, President of AT&T South Carolina
Dr. Eric Lacy, PI for Marine Genomics, MUSC
Dr. Steve Lanier, Associate Provost for Research, MUSC
The Honorable Hugh Leatherman, South Carolina Senate, Chairman of Senate Finance Committee
Dr. Fran Lee, Director of Instructional Operations, Clinical Effectiveness and Patient Safety CoEE, MUSC
Ms. Angie Leidinger, Executive Director, Office of Government Affairs, Clemson
Dr. Claude Lilly, Dean, College of Business & Behavioral Science, Clemson
Prof Jim London, Assoc Dean for Research, College of Architecture, Arts & Humanities, Clemson

Mr. Bill Mahoney, CEO, South Carolina Research Authority
Dr. Roger R. Markwald, Chair, Department of Cell Biology and Anatomy, MUSC
Ms. Casey Martin, Director of Governmental Affairs and Legislative Liaison, USC
Dr. Michael Matthews, Chair, Department of Chemical Engineering, PI for Rehabilitation and Reconstruction, USC
Ms. Lisa McGill, Government Relations, MUSC
Dr. Robert McKeown, Chair of Epidemiology/Biostatistics, USC
Mr. Edward McMullen, Board Member: (2002-07) and Former Chair, CoEE Review Board
Ms. Clare Morris, Clare Morris Agency, CoEE Contracted Marketing Agency
Mr. Gregg Morton, Former member, CoEE Review Board
Ms. Darla Moore, Vice President, Rainwater, Inc.
Dr. Paul Simon Morgan, CoEE Endowed Chair, Brain Imaging, MUSC
Dr. Gail Morrison, CHE Academic Affairs & Licensing Director, CHE Deputy Director
Dr. Jay Moskowitz, CoEE Endowed Chair for Healthcare Quality and President of Health Sciences South Carolina
Mr. Keith Munson, CoEE Review Board Member

Mr. Karl Novak, Chairman, Board of Directors, MUSC Storm Eye Institute

Mr. Brian O'Rourke, Director of Development and Alumni Affairs, Clemson
Ms. Trisha Ostrowski, Clare Morris Agency, CoEE Contracted Marketing Agency

Mr. John Parks, Executive Director, Innovista
Dr. Harris Pastides, President, University of South Carolina
Dr. Russ Pate, Vice Provost for Health Sciences, Professor in Exercise Science, USC
Dr. Sunil J. Patel, M.D., Clinical Chair, Department of Neurosciences, MUSC
Mr. Bill Payne, Senior Associate, Finance, Kentucky Council on Postsecondary Education
Mr. Robert Pearce, CoEE Review Board Secretary
Dr. Dennis Poole, Co-PI for SeniorSMART CoEE, Dean of Social Work, USC
Dr. Chris Przirembel, VP for Research, Clemson

Mr. James Ramich, Chairman, Board of Directors, MUSC Heart and Vascular Center
Dr. John Raymond, Provost and VP for Academic Affairs, MUSC
Dr. Kenneth Reifsnider, CoEE Endowed Chair of Solid Oxide Fuel Cells, USC
Dr. Jerry Reves, Dean of the College of Medicine, MUSC
Dr. Kathleen Richardson, Chair, School of Materials Science & Eng., PI for Advanced Fiber-Based Materials CoEE, Clemson
Dr. Jim Ritter, Co-PI for Strategic Approaches to Electricity Production from Coal, USC
Mr. Ben Rook, Former CoEE Review Board member, Chair, Secretary
Dr. Jim A. Roberts, OnSite Review Panelist, Professor Dept of Electrical Engineering, University of Kansas

Dr. Iain Sanderson, CoEE Endowed Chair, Healthcare Quality, MUSC
The Honorable Mark Sanford, Governor of South Carolina
Ms. Peggy Schachte, Director, Research Development, MUSC
Dr. John Schaefer, CoEE Endowed Chair, Clinical Effectiveness and Patient Safety, MUSC??
Dr. Rick G. Schnellmann, Ph.D., Chair, Department of Pharmaceutical and Biomedical Sciences MUSC
Mr. Jim Scotti, Fluor VP-CoEE in Supply Chain
Dr. Charles Smith, CoEE Endowed Chair, Cancer Drug Discovery and CoEE Cancer Cluster, MUSC
Mr. Hilton C. Smith, Jr., Board of Directors, Spaulding-Paolozzi Foundation
Dr. Andrew Sorensen, Former President, USC
Dr. Caron St. John, Assoc Dean for Research, College of Business & Behavioral Science, Clemson
Mr. Mark Sweatman, Government Relations, MUSC
Mr. Ted Stern, Member, Board of Directors Spaulding Paolozzi Foundation
Dr. Richard Swaja, CoEE Endowed Chair, Regenerative Medicine and PI for Advanced Tissue Biofabrication CoEE, MUSC

The Honorable Joe Taylor, South Carolina Secretary of Commerce
Mr. Samuel Tenenbaum, former CoEE Review Board member
Ms. Brenda Thames, Vice President for Academic Development, Greenville Hospital System

Dr. John Van Zee, PI for Hydrogen and Fuel Cell, PI for Renewable Fuel Cells, USC
Dr. Paul Venhovens, CoEE Endowed Chair in Automotive Systems Integration, CU-ICAR
Dr. Tom Vogt, PI for CoEE in Nanoenviromental Research and Risk Assessment and Director of the NanoCenter, USC

Margaret Wagner-Dahl, Director of Business and Economic Development, Georgia BioBusiness Center
Dr. Tony Waldrop, OnSite Review Panelist, University of North Carolina at Chapel Hill
Dr. Garrison Walters, CHE Executive Director
Mr. Ed Walton, Associate Vice Provost for Academic Resources, USC
Mr. John Warner, President, Swampfox
Dr. Richard Webb, CoEE Endowed Chair, Nanostructures, USC
Mr. Melvin Williams, CoEE Review Board Member
Dr. M. Edward Wilson, M.D., Chair, Department of Ophthalmology, MUSC
Mr. Larry Wilson, Venture Partner, Pequot Ventures
Mrs. Patricia Wilson, Member, CoEE Review Board
Ms. Sandy Woodward, Public Affairs, Clemson

Dr. Chris Xue, Associate Faculty, CoEE in Solid Oxide Fuel Cells, USC

Mr. Bart Yancey, Associate Chief of Staff, Office of the President, MUSC

Dr. John Ziegert, CoEE Endowed Chair in Automotive Design & Development, CU-ICAR
Dr. Michael R. Zile, PI for CoEE in Molecular Proteomics for Cardiovascular Disease and Prevention, MUSC

Appendix B

Other State Programs

In conducting its evaluation of the S.C. CoEE program, the WAG evaluation team drew not only on the findings from the document review, on-site visits and interviews, but also on a comparison with regional programs having similar objectives, specifically Kentucky's Bucks for Brains program, the Georgia Research Alliance, and the early development of the Research Triangle and university-based economic development programs in North Carolina as described in the sections below.

Kentucky Bucks for Brains

"Bucks for Brains", the Kentucky endowed chair and professorship program, started in 1998 and is one of several major higher education funding programs in the state. Bucks for Brains received an initial installment of $110 million in funding in its first year from the state's General Fund, and two subsequent installments of $120 million each in state bond funds in 2002 and 2004, for a total of $350 million.

The University of Kentucky (UK) and University of Louisville (UL), the state's public research universities, were eligible to receive $300 million of the $350 million, with UK eligible for two-thirds ($200 million) and UL for one-third ($100 million). The state's comprehensive (i.e. non-research) universities were eligible for $50 million in funding.

Like the CoEE program, Bucks for Brains requires a 100% match, so the total potential investment over 10 years has been $700 million. The state funds go into a Research Challenge Trust Fund overseen by the Council on Post-Secondary Education before being awarded to the universities.

The important similarities and differences between Bucks for Brains and the CoEE program include:

- The non-state match in Kentucky can come from a wide variety of sources, including companies, foundations, and individual donors. Individual donors have become increasingly important in Kentucky over time, and are likely to become so in South Carolina as well. The emphasis on corporate donations in South Carolina is well-placed, but the clarification in the CoEE legislation from "private sector" to "non-state" was important for the state to obtain the full leverage of matching funds.

- Unlike in South Carolina, where 60% of the match amount can be used to support the direct costs of a Center, the entire match amount goes into the university endowment to support the endowed chair in Kentucky. Kentucky provides financial support separately for research infrastructure and equipment.

- Unlike in South Carolina, there is no requirement that Bucks for Brains endowed chairs or professors be newly recruited into the state, and the appointments have been promotions of current UK and UL faculty as well as new recruits to the state. The lack of an out-of-state hiring emphasis is a weakness of the Kentucky program compared the CoEE program, in the opinion of the evaluation team.

- Unlike in South Carolina, science and technology are not the sole focus. Bucks for Brains endowed chairs can be professors of theater arts or religion as well as clean coal specialists or nanotechnologists. This aspect of the Kentucky program diminishes the economic development value of the program, but enhances its value as an institutional development program for the universities.

- Bucks for Brains is a "pass through" program. There is no CoEE Review Board equivalent, and no external peer review is used beyond the university's standard procedures for tenure and promotion. This is a weakness of the Kentucky program compared to the CoEE program, in the opinion of the evaluation team.

- Economic development is not a consideration in decisions about how Bucks for Brains funds get allocated. The program's goals are for UK to become a Top 20 public university and for UL to become a "premier metropolitan university."

For these reasons, while Bucks for Brains has been and continues to be a valuable tool for faculty development and institutional advancement, its economic impacts on the State of Kentucky do not appear to be as profound or far-reaching as the impacts of the CoEE program on the State of South Carolina. On the other hand, the Kentucky program underpins a broader range of education and research programs than the CoEE program, and may have a bigger impact on the universities' core mission.

The Kentucky program has a number of features that could be of interest to South Carolina. For example, Bucks for Brains releases funds at a lower threshold than the CoEE program, and funds endowed professorships as well as endowed chairs. $500,000 in non-state match is needed for an endowed chair, and only $250,000 for an endowed professorship. The lower funding threshold enables the universities to identify and reward "rising stars" on the faculty, and also to approach and cultivate potential donors for lower dollar amounts.

In Kentucky, the state money is released to the university endowment as soon as the pledge is received. (The pledge letter is signed both by the donor and by the university president, and is reviewed by the university Board of Trustees.) The university has five years from the pledge date to secure the funds, and if a donor reneges on a pledge, the university has 180 days to find a replacement gift, which must be in cash. According to the Kentucky Council on Post-Secondary Education, the default rate on pledges has been very low. This policy permits the release of state funds more quickly in Kentucky than in South Carolina, where the non-state funds must be "in hand" at the universities before the state money is released from the CoEE Matching Endowment. Despite the thrust of Recommendation #3 above, the evaluation team does not recommend that South Carolina adopt the Kentucky "release on pledge" approach without a study of the potential negative impact that this could have on the universities if and when pledges are not received.

In the first 10 years of Bucks for Brains, the Kentucky universities have obtained matching funds for 211 endowed chairs (159 appointed so far) and 312 endowed professors (227 appointed so far). The Research Challenge Trust Fund kept the interest income from non-expended appropriations in the first round of funding, and the state has kept it in the second and third rounds. In 2008, the State of

Kentucky appropriated $60 million in bond money in a fourth round of Bucks for Brains funding, which the universities can use either for endowed chairs or for capital projects, bringing the total program investment to $410 million.

Georgia Research Alliance

The Georgia Research Alliance (GRA) is a 501(c)(3) corporation with a Board of Trustees that involves business leaders, state leaders, and university presidents. The GRA philosophy is summarized by "Body, Mind, Spirit", as in:

- Body of knowledge – breakthroughs needed by business
- The best minds in the research universities to develop further innovations
- Entrepreneurial spirit that creates wealth by moving new knowledge into the marketplace

The GRA started with a program "to attract the world's preeminent scientists to lead extraordinary programs of research and development at affiliated Georgia research universities."

Since 1990, over 60 Eminent Scholars have been named at six eligible research universities: Medical College of Georgia, University of Georgia, Georgia Tech, Georgia State, Emory, and Clark Atlanta. Most of the Eminent Scholars have been appointed at Emory, Georgia Tech, Medical College of Georgia, or the University of Georgia, the leading research universities in the state.

The first Eminent Scholar was not a new hire, but a key retention. A prominent faculty member in the field of information technology was being recruited to Florida. Instead, he was named an Eminent Scholar, stayed in Georgia, and subsequently founded a successful Internet security company. Subsequent Eminent Scholars have primarily been new hires from out-of-state.

The costs of the GRA organization are paid by contributions from Board members and business leaders in Georgia, and the costs of its programs and awards are paid by funding appropriations from the state. The overhead costs are estimated to be about $1 million annually, and the GRA organization has received between $20 and $40 million per year from the Legislature.

According to the GRA, the $467 million in total state investment in GRA programs since 1990 has generated $2 billion in federal and private funding, a 4-1 return; 5,500 new science and technology jobs; and 150 new companies.

The GRA is structured to be lean and nimble, and its funding programs have evolved significantly over time. Since 1990, $467 million has been invested in three programmatic areas. In addition to Eminent Scholars, the GRA has funded 24 Centers of Research Excellence and funds a major commercialization program whose main activity is a highly innovative program called VentureLab.

The Eminent Scholars and Centers of Research Excellence programs are in many ways direct analogues to the CoEE program. $750,000 in matching university funds is required to endow an Eminent Scholar.

Despite the fact that the first one was already in-state, most of the other Eminent Scholars have been recruited to Georgia from out-of-state to lead or participate in a major new research initiative.

Of the 24 Centers of Research Excellence, the vast majority (20) are in health-related or biomedical fields. The GRA recently launched a major follow-on activity to the Centers of Research Excellence, which includes significant private-sector support: the Next-Generation Vaccines and Therapeutics Initiative.

As the GRA has matured, it has been able to focus more on commercialization and less on laboratories and equipment. In 2002, the universities indicated that that they needed help with technology transfer and commercialization, and worked with the GRA to pilot and launch the VentureLab program. The GRA funds the program based on funding applications submitted by the universities, and each university has a VentureLab Director (with no salary funding supplement from GRA) who works with the academic entrepreneurs and who is not necessarily the Technology Transfer Office Director.

The overall goal of VentureLab is to mitigate the early risk in academic entrepreneurial start-ups, so that by the time they emerge from the program they are commercially "fundable." This structure has enabled each GRA university to develop a VentureLab program specific to its portfolio needs. At Emory, for example, where drug discovery is strong, VentureLab may fund toxicology studies of new compounds. At Georgia Tech, where technology is strong, it might be more about prototyping and beta testing. At the University of Georgia, where plant and animal basic and applied research is strong, the funds may be spent on market research and more typical business planning activities.

There are four VentureLab phases:

- **Phase 1** provides up to $50,000 in grants in two $25,000 tranches. The universities and the academic entrepreneurs decide how this money is spent through the proposal process. The Phase 1 outcome: to determine whether or not a start-up company is viable option for innovation transfer.
- **Phase 2** provides up to $100,000 in grants in two $50,000 tranches. In this phase, the company is incorporated, the start-up management team is being acquired, and the business plan is solidified with clear capitalization milestones. Up to $50,000 in matching funds is required in this phase, for example, SBIR, STTR or angel funding.
- **Phase 3** is a loan of up to $250,000 in two $125,000 tranches. The loan is made directly to the company on favorable terms, but with penalties if the company leaves the state.
- **Phase 4**, which is currently being developed, is the opportunity to receive venture funding. Georgia has a well-developed funding infrastructure for technology, but a limited infrastructure for biosciences. GRA has started a venture fund with $7.5 million in state money, which will be matched 3:1. The $30 million will be placed in a captive fund for approximately 20 qualifying VentureLab companies.

The VentureLab program has been cited for its staged approach to commercialization, and could be a useful model for SCLaunch at SCRA and for the CoEE program. VentureLab serves all of the academic

entrepreneurs at the GRA universities, not just the Eminent Scholars, but, in the words of one VentureLab Director, "the Eminent Scholars are the low-hanging fruit."

VentureLab funding has to flow through the universities due to a State of Georgia gratuities law that prohibits direct state grants to individuals. We recommend that the technology transfer offices in the universities be included in whatever program develops in South Carolina, but, as in Georgia, they do not necessarily need to be given the lead responsibility. The current level of GRA funding for VentureLab is approximately $4 million per year.

The GRA offers at least three key lessons for the CoEE program: 1) the value of consistent funding over time, even if the annual levels vary; 2) the value of flexibility in the uses of funding, as the program matures and state needs evolve over time; and 3) the value of a centrally coordinated but decentralized approach to management of commercialization and technology transfer. It is noteworthy that VentureLab was introduced relatively late in the GRA program development, more than a decade after the first Eminent Scholar was hired.

North Carolina Research Triangle Park[19]

The North Carolina Research Triangle Park (RTP), the world's largest and most successful university-related research park, was founded in 1959. Its early history provides valuable insights for the CoEE program.

The Park was initially conceived as a for-profit enterprise with the support of then-Governor Luther Hodges and business leaders in the state. In 1959, the non-profit Research Triangle Foundation, created with donations from 450 individuals, bought out the original investors and became the managing entity. The Park's first tenant was the Research Triangle Institute, a non-profit contract research organization for the faculty of Duke, the University of North Carolina, and North Carolina State University. Unlike in South Carolina, where the research universities are located in different regions of the state, RTP's three university partners are all located within 20 miles of the Park.

North Carolina's economy in the 1950s was poor. The state's per-capita income ranked 49th in the nation, the economy was concentrated in low-wage industries of tobacco, textiles and furniture, and the state suffered from "brain drain."

[19] The information in this section is drawn from "A historic conversation," a Southern Oral History Program interview with William Friday, William F. Little, and George L. Simpson, Jr., published as a DVD by the Research Triangle Park; and from "North Carolina's Research Triangle Park: Overview, history, success factors and lessons learned," by John W. Hardin, Chapter 2, pp. 27-51, Pathways to High-tech Valleys and Research Triangles: Innovative Entrepreneurship, Knowledge Transfer and Cluster Formation in Europe and the United States (Springer, 2008). The Hardin chapter is published on the Web at http://library.wur.nl/frontis/research_triangles/02_hardin.pdf See also: http://www.klv.nl/hulsink/Hardin_Presentation_Research_Triangle_Park.pdf.

RTP's first corporate tenant was the Chemstrand Corporation. RTP made the connection to Chemstrand in 1959 through the company recruiter who was visiting the campuses to hire graduate students. IBM, the second corporate tenant, did not come until six years later, and its arrival marked the turning point in RTP's success. IBM was courted heavily by then-Governor Terry Sanford. One of the main reasons it came to RTP was because Fred Brooks, a former IBM researcher and the developer of the IBM System 360 mainframe computer, had been named the founding chairman of the UNC computer science department, the first of its kind in the country. IBM is still the largest tenant in the Park and RTP is the second-largest IBM site in the world, with nearly 12,000 employees.

For Chemstrand and IBM, the availability of world-class graduate programs and a high-quality graduate workforce were critical factors in the business location decision.

According to George Simpson, the Executive Director of the founding Research Triangle Committee, the ability of the Institute and the Park to market the intellectual assets of Duke, UNC and N.C. State was also central to RTP's success. "We were building, not another industrial park, but a union of effort aimed at research to create new discoveries, new methodologies, new ways of doing things," Simpson says. "Once you turn it into a colony of manufacturing plants you've lost the genius that was behind the idea from the very beginning."

RTP changed the culture and the economy of North Carolina and was able to capitalize on the post-Sputnik boom in science and engineering. The Park has enjoyed steady growth over the years. The National Institute for Environmental Health Sciences was offered space in 1966, and Burroughs Wellcome (now Glaxo), Becton-Dickinson, and the Environmental Protection Agency became anchor tenants in the 1970s. Burroughs Wellcome already had a manufacturing facility in the state and was RTP's first international tenant when it located its North American R&D headquarters there. University spin-off companies were not part of the original strategic plan. According to Simpson, "We had to have the base" of large-company tenants to become profitable. By the mid-1970s, the RTP development debt was retired and the Research Triangle Foundation set aside land for use by the National Humanities Center and university start-up companies.

The non-profit RTP Foundation also has the flexibility to sell land in the Park to tenants with a tax-advantaged benefit. The Park is not subject to annexation by Durham or Raleigh, and the tenants do not have to pay city taxes on their land or buildings.

In terms of current economic impact:

- Total payroll in RTP is over $2.7 billion
- 140 companies employ 38,500 employees (over 44,000 including contract employees)
- Annual purchases per RTP employee is about $60,000
- All 100 counties in N.C. have a connection to RTP companies

- Over 1,000 technology-based start-ups and spinoffs are located in the Triangle area, many started by RTP organizations
- The number of start-ups/spinoffs has doubled every 5 years since 1970

The state of North Carolina has never funded an Endowed Chairs program like the CoEE. Instead, the state has provided above-average appropriations and general obligation bond funding to the public universities, so the research quality is high and the facilities and infrastructure are modern and up-to-date. In general, it could be stated that the success of the Research Triangle and North Carolina's consistently high level of General Fund appropriations and bond funding for higher education has made a CoEE-like program unnecessary in the state. In the 2007-08 fiscal year, North Carolina ranked 5th in the nation in state higher education appropriations ($3.7 billion, not including capital improvements), even though it ranks 10th in population.[20] In 2000 the voters approved the $3.1 billion N.C. Higher Education Bond Referendum, which included $500 million in capital spending for the flagship UNC-Chapel Hill campus. In order to compete effectively with its neighbor to the north, South Carolina will need to increase its base level of funding for higher education, as well as to continue funding the CoEE program for the senior research universities. The creation of S.C. LightRail, on the other hand, makes it unnecessary for South Carolina to develop a geographically-focused research park like the Research Triangle Park. Instead, South Carolina has the opportunity to develop mini-RTPs along the lines of CU-ICAR, in smaller, more highly-focused university-based economic development zones interlinked by high-speed fiber optic networking across the state.

[20] Dale Gibson, "No Paupers to Be Found in UNC System," *Triangle Business Journal*, January 18, 2008.

Appendix C

CoEE Centers by Research Area/Industrial Sector

Funding Year	Institution(s)	Proposal	Research Area	Industrial Sector
2002-03	Clemson	Automotive Systems Integration	Automotive	Adv Manufacturing
2002-03	Clemson	Automotive Manufacturing	Automotive	Adv Manufacturing
2002-03	USC	Nanostructures	Adv Manufacturing	Adv Manufacturing
2002-03	USC/MUSC	Brain Imaging	Healthcare	Healthcare
2002-03	MUSC	Proteomics	Healthcare	Healthcare
2002-03	MUSC	Neuroscience	Healthcare	Healthcare
2002-03	MUSC/Coll of Charles.	Marine Genomics	Environment	Energy & Environment
2003-04	Clemson	Automotive Design & Development	Automotive	Adv Manufacturing
2003-04	Clemson	Electronics Systems Integration	Automotive	Adv Manufacturing
2003-04	Clemson	Photonic Materials	Electronics	Adv Manufacturing
2003-04	USC	Polymer Nanocomposites	Adv Manufacturing	Adv Manufacturing
2003-04	USC	Hydrogen & Fuel Cell Economy	Energy	Energy & Environment
2003-04	MUSC/Clemson/USC	Regenerative Medicine	Healthcare	Healthcare
2003-04	MUSC/USC	Translational Cancer Therapeutics	Healthcare	Healthcare
2004-05	USC	Renewable Fuel Cells for Fuel Cell Economy	Energy	Energy & Environment
2004-05	USC	Hydrogen & Fuel Cell Economy	Energy	Energy & Environment
2004-05	USC/Coastal Carolina	Travel & Tourism	Tourism	Energy & Environment
2004-05	MUSC	Gastrointestinal Cancer Diagnostics	Healthcare	Healthcare
2004-05	MUSC/USC	Cancer Drug Discovery	Healthcare	Healthcare
2004-05	MUSC/USC	Vision Science	Healthcare	Healthcare
2005-06	Clemson	Supply Chain Optimization & Logistics	IT	Adv Manufacturing
2005-06	Clemson	Urban Ecology & Restoration	Environment	Energy & Environment

Funding Year	Institution(s)	Proposal	Research Area	Industrial Sector
2005-06	Clemson	Advanced Fiber-Based Materials	Adv Manufacturing	Adv Manufacturing
2005-06	Clemson	Molecular Nutrition	Healthcare	Healthcare
2005-06	USC	Solid Oxide Fuel Cells	Energy	Energy & Environment
2005-06	USC/MUSC	Childhood Neurotherapeutics	Healthcare	Healthcare
2005-06	MUSC	Molecular Proteomics in CV Disease & Prevention	Healthcare	Healthcare
2005-06	MUSC/USC	Clinical Effectiveness & Patient Safety	Healthcare	Healthcare
2006-07	Clemson/MUSC	Health Facilities Design and Testing	Healthcare	Healthcare
2006-07	USC	Rehabilitation and Reconstruction Sciences	Healthcare	Healthcare
2006-07	USC	Strategic Appr. to Electricity Prod. from Coal	Energy	Energy & Environment
2006-07	USC/MUSC/Clemson	Healthcare Quality	Healthcare	Healthcare
2006-07	USC/Clemson	SeniorSMART™ Center	Healthcare	Healthcare
2006-07	MUSC	Tobacco-Related Malignancy	Healthcare	Healthcare
2006-07	MUSC/USC	Stroke	Healthcare	Healthcare
2007-08	Clemson	Optoelectronics	Electronics	Adv Manufacturing
2007-08	Clemson	Cyber-Institute	IT	Adv Manufacturing
2007-08	USC	Nanoenvironmental Research & Risk Assessment	Environment	Energy & Environment
2007-08	USC	Nuclear Science and Energy	Energy	Energy & Environment
2007-08	MUSC	Renal Disease Biomarker	Healthcare	Healthcare
2007-08	MUSC/Clemson	Cancer Stem Cell Biology & Therapy	Healthcare	Healthcare
2007-08	MUSC/USC/Clemson	Advanced Tissue Biofabrication	Healthcare	Healthcare
2007-08	MUSC/USC/SCSU	Cancer Disparities	Healthcare	Healthcare
2007-08	MUSC/USC	Medication Safety & Efficacy	Healthcare	Healthcare

Appendix D

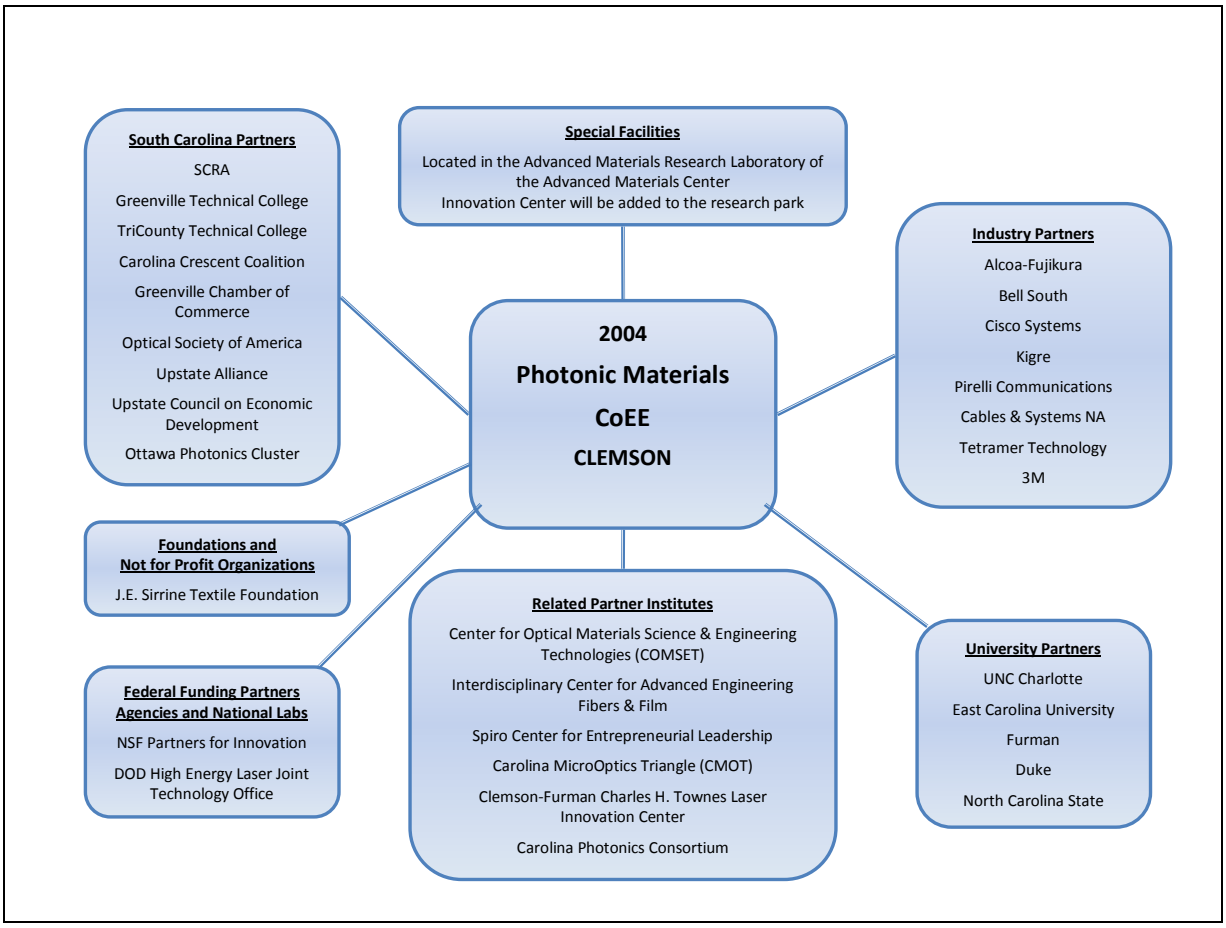
CoEE and University Spin-off Companies

Institution	Year	Spin-Off Companies Created	Employment
USC	FY 2003	Integrated Analytics	
	FY 2004	Direct Measurement, Inc	
		ZDD	5
	FY 2005	Getting to Outcomes	
		Inhibix Technologies	2
		IDV	12
		Opton Technologies	
		R&H Assoc of Columbia	
		Correlated Solutions	7
	FY 2006	Carbonix, LLC	2
		Inflamma Tech, LLC	
		Geogenetics, Inc	2
		Palmetto Fuel Cell Analysis and Design [CoEE]	2
		Denergy [CoEE]	2
	FY 2007	DPX Labs, LLC	
		Nitek	1
		FAMO, LLC	2
		Nano Solutions Technologies, LLC	
		Hydrogen Hybrid Motility, LLC	2
		AlphaPore, Inc	
	FY 2008	Palmetto Bioscience, LLC	
		PDNT Pharmaceuticals	
		LuminOF, LLC	2
		Vitasol	
Clemson	FY 2005	Tetramer Technologies, LLC [CoEE]	20
		Advanced Photonic Crystals [CoEE]	3
	FY 2006	Kiyatec, LLC	1
		Specialty Custom Fibers, LLC [CoEE]	2
		Andrew Clark	1
	FY 2007	BalancedFlow Supply Chain Solutions, LLC	0
		iTography, LLC	2
		Selah Technologies, LLC	8
	FY 2008	Earth Renewable Technologies, LLC	2
		SensorTech, LLC	7
		Smart Blending Technologies, LLC	

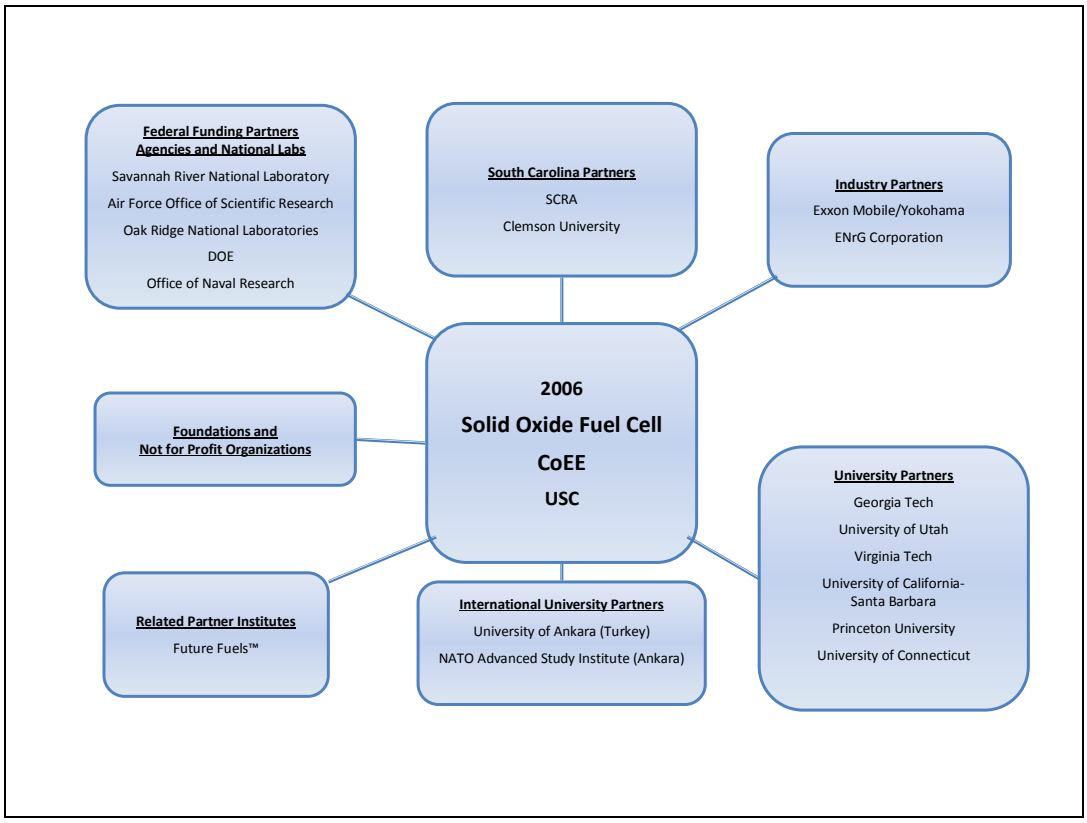
Institution	Year	Spin-Off Companies Created	Employment
MUSC	FY 2003	Argolyn	4
		Biowhite	1
	FY 2004	Online Medical Education	
	FY 2005	Cephos [CoEE]	7
	FY 2006	FirstString Research [CoEE]	3
		Immunod [CoEE]	1
	FY 2007	SemiAllogene [CoEE]	
		Sphingogene	
	FY 2008	Phigenix	2
		Microbial Fuel Cell Technologies	2

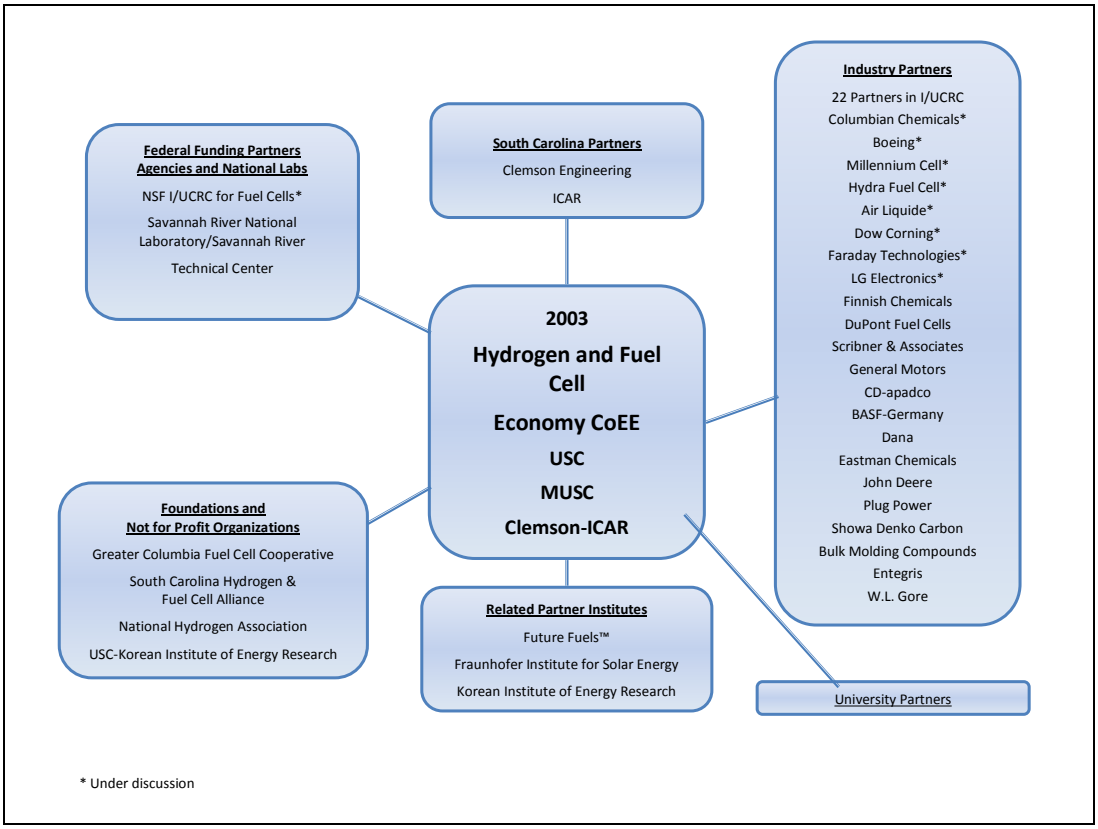
Appendix E

Exemplary Center Partnerships

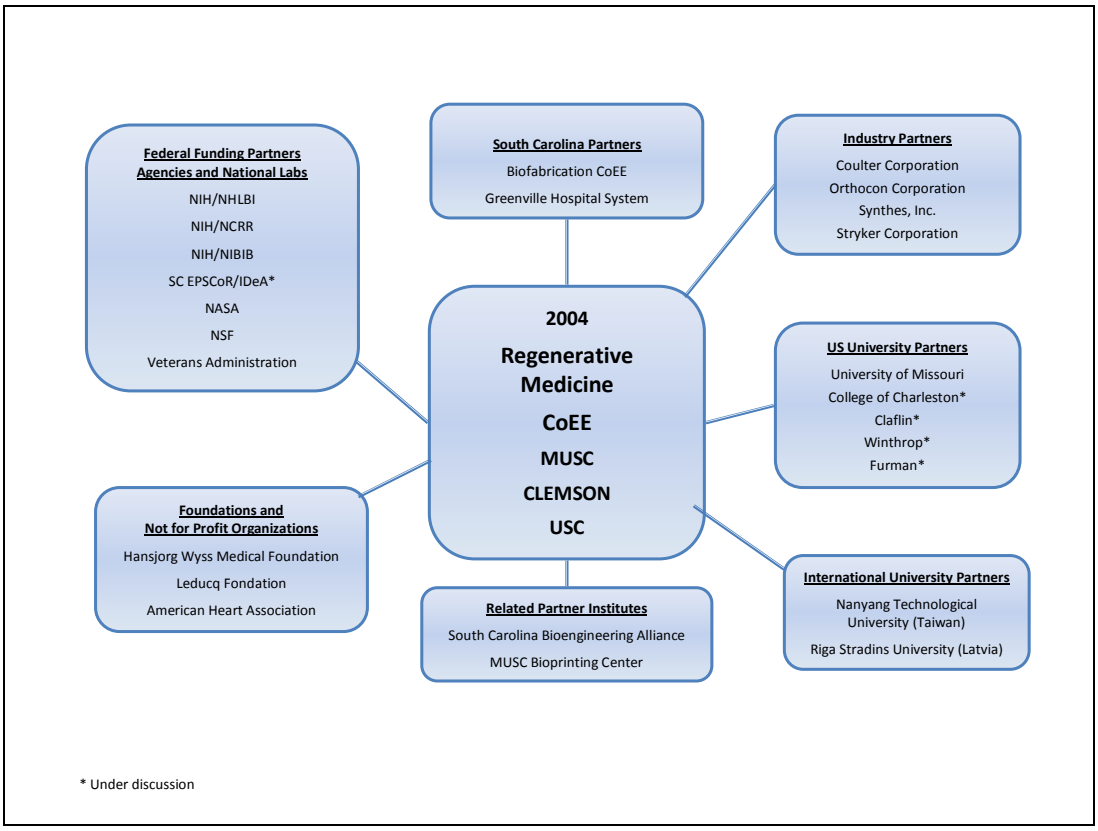


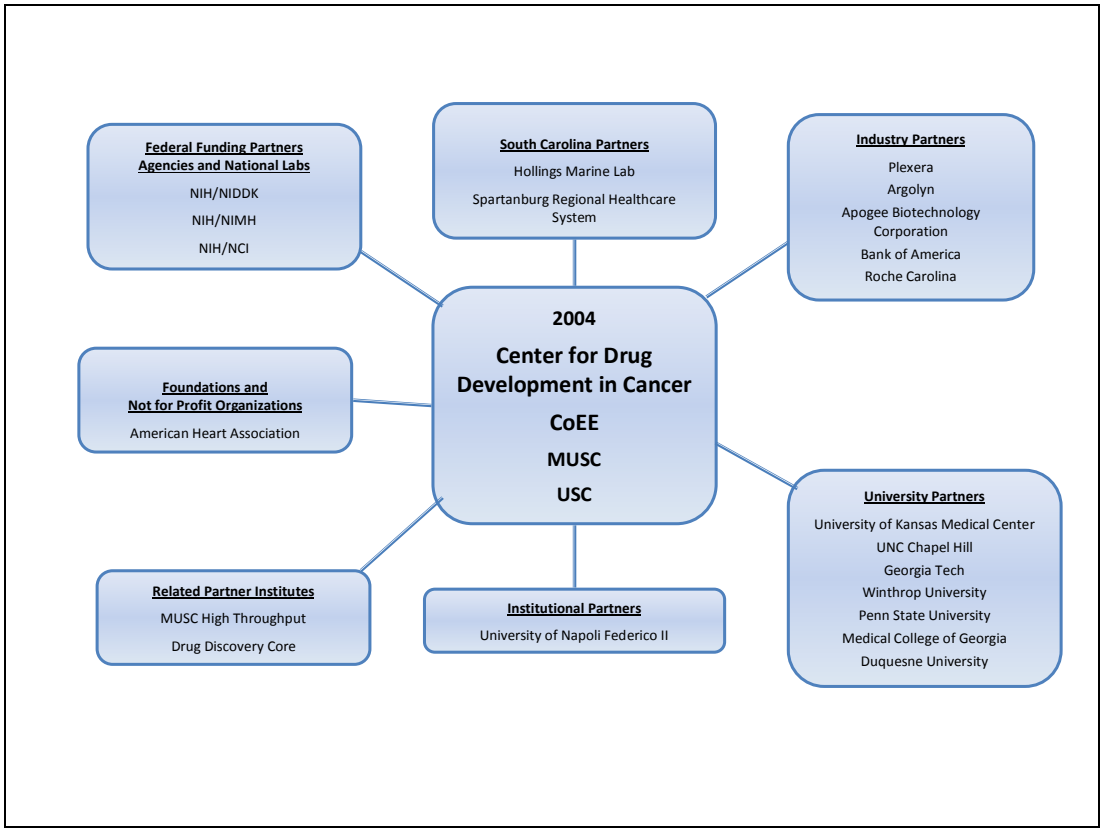
NOTE: "Partnerships" refer to those relationships with industrial, business and private sector entities through research partnerships (grants), donations of special equipment and direct investment in the CoEE.





NOTE: "Partnerships" refer to those relationships with industrial, business and private sector entities through research partnerships (grants), donations of special equipment and direct investment in the CoEE.





NOTE: "Partnerships" refer to those relationships with industrial, business and private sector entities through research partnerships (grants), donations of special equipment and direct investment in the CoEE.

Appendix F

CoEE Corporate Partners

3M
Advanced Medical Optics (AMO)
Aerospace Engineering
Aerotech Corporation
AGS Resources
Air Liquide
Alabama Power and Electric
Alcoa-Fujikura
Alcon Labs
Allergan
AlphaGenesis, Inc.
Alteon, Inc.
American Titanium Works
Apogee Biotechnology Corporation
Argolyn
Astellos Pharma US, Inc.
AstraZenaca
AT&T
Automation Engineering Corp.
AVX
Bank of America
BASF-Germany
Bausch & Lomb
Bell South
Biogenar
BioValve
B-Line Medical
BMW
Boeing
Bridgestone
Bulk Molding Compounds
CAD FEM (GmBH Germany)
Caldwell Banker Caine Real Estate
Cara Therapeutics
CD-apadco
Central Electric Power Cooperative
Cephalon Pharmaceuticals
Cephos Corporation (Oxford Bioventures)
Charles River Endosafe
Cisco Systems
Collexis
Columbian Chemicals
Coulter Corporation
C-TASC (Clinical Trials & Surveys Corp.)
Cyberonics
Daimler-Chrysler
Dale Earnhardt, Inc.
Dana
Dialysis Clinics, Inc
Dow
Dow Corning
DuPont
DuPont Fuel Cells
Eastman
Eastman Chemicals
EnginSoft
ENrG Corporation
Entegris
Exxon Mobile/Yokohama
Faraday Technologies
FEV Systems
Finnish Chemicals
Fluor
Force Protection Industries
Furman Co.
GE
Genentech
General Motors
Glaxo-Smith Kline
HealthPathways
Hewlett Packard
Honda
Hydra Fuel Cell
IBM
ImmunoMod, Inc.
Inotek
INTEC US
IntelliTrans Solutions
Janssen Pharmaceuticals
Jazz Pharmaceuticals

NOTE: "Partnerships" refer to those relationships with industrial, business and private sector entities through research partnerships (grants), donations of special equipment and direct investment in the CoEE. *Italicized* company name indicates relationship is under discussion.

John Deere
KEMET
Kigre
Laerdal Corporation
Lexicon Pharmaceuticals
LG Electronics
Lilly Pharmaceuticals
Lockheed Martin
Lutheran Homes of South Carolina
Marlow Industries
Martec
Mazda
MeadWestvaco
Medtronics
Members of the Clemson Vehicular Consortium
Merck
Michelin
Millennium Cell
Morris South
MTS
NEC
Nelson Mullins Riley & Scarbrough, LLP
New Chapter, Inc.
Nissan
Novartis
Novelos Therapeutics
Okamura
Okuma America Corp.
Ortho Diagnostics
Orthocon Corporation
OSI Pharmaceuticals
Ozen Engineering
PBI Performance Products
Pfizer
Philips Research
Pirelli Communications Cables & Systems NA
Plexera
Plug Power
Prudential C. Dan Joyner Co
Renk
Ricardo
Richard Petty Driving Experience, Inc
Robert Bosch Co.
Roche Carolina
Samsung
Scribner & Associates
SeaGate Technology
Showa Denko Carbon
Shrimp Improvement Systems
Siemens
Siemens Medical USA
Smith & Nephew
Southern Company
SpA (Italy)
Staubli
Stryker Corporation
Sun MicroSystems
Synthes, Inc.
Taiho Pharmaceuticals
Taligen
Tetra Precision, Inc.
Tetramer Technology
Timken
Toyota
W.L. Gore IBM
Weiss
Young Office Workspaces
Zeiss
Zuken

NOTE: “Partnerships” refer to those relationships with industrial, business and private sector entities through research partnerships (grants), donations of special equipment and direct investment in the CoEE. *Italicized* company name indicates relationship is under discussion.